THE
AMERICAN NATURALIST

VOL. LXX *January–February, 1936* No. 726

CONSEQUENCES OF SELECTION IN *LYTHRUM SALICARIA*

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FISHER (1935) has recently calculated the mathematical consequences of selection on populations of *Lythrum salicaria* under the factorial interpretation proposed by East (1927) to account for the behavior of certain aberrant mid-styled plants. This interpretation postulated two linked factors M_a and M_b having a crossover value of about 10 per cent. Four genotypes of mid-styled plants are possible under these assumptions, M_a, M_b, M_aM_b and M_a/M_b, depending on whether the genes concerned are single, paired in a single chromosome or opposed in homologous chromosomes. The presence of both genes in the homozygous condition was considered to be lethal, though it was shown later (East, 1932) that at least one of the M genes (and perhaps either) might exist in the homozygous condition, when single, without detriment to the individual. The presence of gene A modified mid-styled plants to short-styled plants. Plants of constitution $aam_am_am_bm_b$ were long-styled.

Fisher states that East withdrew this theory in 1932 without replacing it, and considers that this withdrawal may have been premature. This statement is not entirely correct. The situation really is as follows. Mrs. Barlow (1913, 1923) found that most of the results on *Lythrum salicaria* could be explained by a simple two-factor scheme

in which long-styled plants are aabb, mid-styled plants are aaBb (or BB) and short-styled plants are AaBb (or AA, or BB). Homozygosity of the positive factors tends to be prevented by self- and cross-sterility of like forms. Mrs. Barlow did not offer this factorial interpretation in either of her papers, however, because of the behavior of certain aberrant mids which threw small percentages of longs. It was suggested by Miss von Ubisch in 1921.

Similar aberrant behavior of certain mids led East to propose the theory outlined above. It was called a balanced lethal theory, because it resembled Muller's balanced lethal theory in its physiological attributes; though, as Fisher states, it is not a true balance of lethals. It was not withdrawn in 1932. On the contrary, it was considered the best interpretation of the facts after the consideration of two other possible theories. It was withdrawn merely as a theory applicable to trimorphism in general, because the simple two-factor theory was sufficient to explain the behavior of the plants found in the wild. It was retained for the exceptional mids, because their behavior had been consistent throughout a long period of experimentation. But they formed a special case. They were members of one stock and possibly were descended from a single plant. Mrs. Barlow had worked with them, and then had kindly sent some of them to East for further investigation. In other words, ordinary mids behave as if they are conditioned by a single gene which behaves in expected fashion. Only this one strain of mids, so far as has been determined definitely, requires the so-called balanced lethal interpretation.

All this is not particularly important, of course, and the present note would not have been written had not Fisher made a suggestion of particular interest to students of evolution. He has calculated the trend of a wild population of the exceptional Lythrums in which all possible constitutions are present in designated frequencies, under the assumption that "the inviability of some zygotes does not affect maternal fertility, which is re-

garded as dependent on the nutritional condition of the seed-bearing parents, and further that the additional seeds produced have the same genotypic distribution as the other viable seeds borne by the same type of mother plant." It was impractical to deal with variables, such as the amount of self-fertility exhibited and other similar biological factors that might be involved; but, neglecting them, Fisher has worked out the contribution of different genotypes to the ancestry of successive future generations. The especially significant result is the apparent selective effect of the elimination of the homozygotes of M_aM_b on linkage intensity. The author takes special interest in the fact that the stability of both M_a and M_b is determined by the superiority of the survival value of the heterozygote over the homozygote, since he had previously discussed the evolutionary consequences of such mechanisms in connection with various polymorphic animals. And he is struck by the possibility that linkage intensity may be selected under natural auspices until it becomes complete. In case this end point should be reached, the peculiar situation occasioned by the linked M's of the so-called balanced lethal hypothesis would pass into the situation controlled by the single M (or B) of the two-factor hypothesis. If changes of this nature can come about, the fact is one of considerable importance to evolutionary theory. What is the likelihood that they occur? We have a basis for judgment in what is known about the linkage mechanism.

Linkage is primarily a phenomenon dependent upon the method by which genes are distributed at meiosis. It is an affair of the chromosomes, for the chromosomes are the freight cars which cart the genes around during the process. Were it not that there are ways by which these freight cars can be coupled together in a rather permanent way and means by which the contents of the cars can be transferred to other cars, even the alignment of the contents would be of no importance. For example, there is no crossing-over in the males of *Drosophila*

melanogaster. This means that the chromosomes are sealed cars, passing their contents along intact in their movements. It makes no difference, therefore, how the genes are arranged. Linkage is complete, and remains complete.

Of course another means of bringing about complete linkage is imaginable. Two or more chromosomes belonging to the same genom might be compelled, by some definite force, to enter the same daughter cell at meiosis. But no such force is known to exist. (It is known that, in Lythrum, chromosome distribution is normal.)

Linkage is not usually complete, as in the Drosophila male, however. Breaks are frequent, and are important. By studying them, geneticists have learned many of the details of germ-plasm architecture and numerous methods of gene distribution. There are three ways indicated by which changes in linkage intensity can be brought about.

A simple translocation of a block of genes will transfer members of one linkage group to another. Independent genes A and B can become linked, or linked genes A and B can become independent. Reciprocal translocations form a variation of this process and often result in ring formations of two or more pairs of chromosomes, thus bringing into one linkage group great blocks of genes formerly independent as blocks. A secondary result of this last transformation is the reduction of normal crossing-over between homologues.

Inversion of a block of genes within a chromosome may cause a change in the linkage values as calculated from normal crossover breaks. Inversions are difficult to establish, however, and can hardly be a factor in our present problem.

Both of these means of producing changes in linkage are saltative in character. They will persist if they become established and may survive in populations over long periods. But by no stretch of the imagination can they be conceived to be selective variables whose fluctua-

tions can be accumulated to change linkage values in the way demanded by Fisher's theory. For this, variations in the normal crossover mechanism appear to be required.

Normal crossover values or breaks in linkage are an accompaniment of chiasma formation. When the two-parted chromosomes come together at synapsis, paired gene-by-gene, they twist about one another. At any of these points of twist a break may come, resulting in a new alignment, provided the same threads do not reunite. Viewed in the simplest way possible, therefore, the factors controlling the crossover frequency of any two genes may be said to be the actual distance separating these genes on the gene string and the amount of twisting involving them. Since the position of the genes on the gene-string remains constant, any change in crossover value would seem to be conditioned by chiasma frequency. The position of the genes would thus bear only on the relative ease or difficulty with which variability in the number of chiasmata affects crossing-over.

But the situation is not so simple as this view makes it appear. Actual gene location is constant for any two genes of a given species; but it makes a difference where the genes are located and how far apart they are, because of interference and of localization. The variable factors are several, and they are more or less interconnected. Ordinary chiasma formation, uncomplicated by aberrant chromosome arrangements, such as reciprocal translocations, takes place in several ways. It may begin near the spindle-fiber, which appears to be the more usual way; it may begin near the ends, as in certain species of Tradescantia; or it may be at random. At all events, there is evidence that in most cases there are preferred locations for the first chiasma; though when the first chiasma is specified, there is no absolute certainty that a crossover takes place. Presumably some chiasmata may break and reunite without crossing-over. Be that as it may, additional crossovers depend upon the location of the first crossover and upon the length of the loop. Natu-

rally, these functions in turn depend upon chromosome length and size, and upon the per cent. of shrinkage between prophase and metaphase.

Chiasma formation, then, is a variable phenomenon. It is variable between species, within species and among the chromosomes of that species. There is no high degree of correlation between chromosome size or shape and chiasma frequency, when different species are compared. There is some association, however, for fat chromosomes, where a large amount of chromatic material is laid on around the gene-string, often show a smaller average number of chiasmata than thin chromosomes. Within a species, there appears to be a somewhat closer association between chromosome size and shape and chiasma frequency. And within a chromosome, though the chiasmata are conditioned in the complex manner just described, there is still a characteristic average that remains rather constant under controlled conditions. Many cytologists go so far as to maintain that crossover frequency is half the value of chiasma frequency, and that chiasma frequency for specified conditions is a constant with a low dispersion coefficient.

From these considerations it follows that crossover frequency—and hence apparent linkage relations—may be changed by a modification of the amount of chromosome shrinkage between prophase and metaphase, by an alteration in the degree of coiling and perhaps by shifting the average of the preferred position for the first chiasma. The minimum extreme is where chiasma formation is prevented entirely. All genes within the chromosome are then completely linked in heredity.

Applying these possibilities to the Lythrum case would mean that if the linkage intensity were altered, then all heterozygotes containing both M's would produce a modified proportion of progeny, due to a different ratio of elimination. It is more difficult to assume, with Fisher, that such alteration would, in turn, tend to produce further alteration. We need not discuss this detail, however,

for the general problem is more important. Instead, we may ask whether there is any evidence supporting the idea that changes of this nature do occur.

It seems reasonable to start with the postulate that the whole meiotic mechanism is a very conservative feature of organisms, for it is similar, in type, in all animals and plants reproducing sexually. Any alterations in it, therefore, may be supposed to concern more or less immaterial points. Yet the reaction most commonly observed in plants is one in which synapsis is prevented entirely. It is produced by both high and low temperatures. It has also been noted, particularly by Sax, that chiasma frequency is different under varied conditions. Presumably these modifications are usually fluctuations which are not hereditary. If it were otherwise, the spread of plants and of cold-blooded animals toward environments of a more extreme character would result in the mechanism's being constantly thrown out of gear. In fact, even diurnal maxima and minima would be extraordinarily effective. Of course, it is possible that observations of Tischler and others concerning the high frequency of polyploid plants at the periphery of many ranges are explained in part by temperature effects on synapsis. But I am inclined to suspect that other explanations will be found.

It seems much more probable that the cause of significant variations in crossover values is to be sought in hereditary chromosome aberrations and in gene mutations. Most of the instances found in Drosophila apparently belong to the first group. The causative agent is deficiency; and an alteration of crossover frequency by such means can not be established. Apparently, therefore, one must depend upon gene mutations. The literature contains several cases in which chiasma frequency, amount of terminalization and proportion of shrinkage between prophase and metaphase are affected in such a manner that gene mutation is suggested. But, so far as the author is aware, there are only two reports where gene mutation is definitely concerned. The first is a mutation

in Matthiola, described by Lesley and Frost (1927) and elaborated by Huskins (1930) and Philip and Huskins (1931), where the per cent. of shrinkage at metaphase is modified. The second is an asynapsis gene in maize discovered by Beadle (1930).

We may conclude, therefore, that linkage values can be modified in several ways. Hence Fisher's suggestion must be given due consideration, even though it may not be sound as he has outlined it, *i.e.*, through selective eliminations. The facts as we have them to-day, however, do not seem to warrant us in treating linkage modification as an important factor in evolutionary procedure. Linkage arrangements are too generally the same everywhere.

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A STUDY OF THE APPEARANCE OF AWN CHARACTERS IN A CROSS BETWEEN MELOY AND FAUST BARLEY[1]

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WHEN hybridizing for economic value the ultimate aim is to produce a high yielding, superior quality, disease resistant variety. The aim of hybridizing when combining economic value with scientific purpose also includes a study of the factors involved, their behavior, genetic composition and expression. When breeding for purely scientific purposes the factors are studied as to their behavior, genetic composition and expression in the succeeding hybrid progeny. The progeny express the parental characters as well as new characters due to the interaction of factors producing new combinations. Occasionally an old parental factor or factors may be lost by the dominance of new factors or by the interaction of factors to produce a new combination.

Most plant breeders who have studied the awned characters of cereals found when crossing two introspecific plants that the F_1 was awnless, while in the F_2 and F_3 generations awned and partially awned types appeared.

Quisenberry and Clark (1933), working on a wheat cross between Sonora and Quality, found that these two awnletted wheats gave a range of segregation in the F_2 from awnless to awned. In the F_3 generation there were obtained true-breeding awnless and awned segregants as well as those awnletted like both parents. From a Supreme X Sonora (awnless) wheat cross, the segregations in the F_2 and F_3 generations indicated a single genetic factor difference.

Love and Craig (1926) reported that when Sonora was crossed with other awnless varieties the F_1 was awn-

[1] Contribution from the Department of Agronomy, University of Idaho, Moscow, Idaho. Published with the approval of the Director as Research Paper No. 124 of the Idaho Experiment Station.

less, whereas awned and partly awned types appeared in the F_2 and later generations.

Taylor and Leighty (1931) found that in intergeneric hybrids between certain species of Aegilops and Triticum the F_1 form tends to reappear exclusively in the later generations. This so-called "constant" hybrid form combines the characters of both parents, but is so different from either of them, it has been suggested that it deserves to rank as a new species.

Clark, Florell and Hooker (1928), working on the inheritance of awnedness in wheat hybrids, classified the progeny into five groups: awnless, apically awnletted, awnletted, short awned and awned. Bobs X Hard Federation, two awnless wheats, gave awnless and apically awnletted hybrids in the ratio of 13:3. Propo (awned) X Bobs or Hard Federation (awnless) showed imperfect dominance of awnlessness in the F_1. The F_2 and F_3 plants were separated into the five classes above. Combining classes 1 and 2 and comparing them with the combined numbers in 3, 4 and 5, the corrected F_2 results for both crosses were statistically close to a two-factor or 9:7 genetic ratio.

Kezer and Boyak (1918) in their investigations found that there is but a single factor difference in crosses involving hoods and awns and that the hooded condition is dominant.

Harlan (1931) states:

> Some Nepal farmer first found hooded barley in the Himalayan mountains about the year 1830–1837. People had searched many years for a beardless barley and then this hooded type appeared. It must have come to the United States soon after it came to Europe as the Genesee farmer of New York mentioned it by name in 1844.

Hooded barley was at least found in Nepal at a time when it had not spread very far east or west of that longitude. Hooded barley probably first appeared as a Mutant in a hull-less barley or Nepal or West China not more than 150 years ago.

In the development of Meloy and Faust barley the following parents were involved: Coast; a six-rowed,

rough-awned variety of north African origin. Nepal; a six-rowed hull-less, hooded barley originating in Nepal, India. Himalaya; a six-rowed hull-less awned barley indigenous to central Asia and the higher altitudes of northern India. Meloy is evidently a field hybrid. It is a six-rowed, hooded, hulled variety which was found in a field of Coast barley grown by George Meloy, of Moro, Oregon. It is thought to be a Nepal-Coast cross.

Faust is a hooded plant selection made by A. J. Faust, of Dillon, Montana, from a field of Himalaya barley.

The cross of Meloy X Faust was made by Ardie Gustafson at the Aberdeen substation, Aberdeen, Idaho, for the purpose of genetically studying the behavior of the elevated hood on Meloy barley in the F_1 and succeeding generations. The appearance of awns in the F_2 generation prompted a further study of the awn characters.

The Meloy-Faust crosses and their reciprocals were made. All the F_1 plants were a hooded hulled type. The hoods were decidedly elevated, more so than on the parent Meloy, but as there was no phenotypic difference, all the progeny were bulked. The F_1 seeds were spotted three inches apart in rows long enough to accommodate all the seed.

The F_2 population, which was all hulled, segregated into the following three classes: smooth-awned, rough-awned and hooded. The non-appearance of the hull-less character of the parent Faust was not included in this study and no effort was made to account for its disappearance. The smooth and rough awn determinations were made by microscopic examination. The rough character varied. Some awns were rough only at the base, others only at the apex. Harlan (1920) found that the awn of some segregants was basically rough and others were apically rough. In this study only awns that were entirely smooth from the base to the apex were classified as smooth; all others were classified rough.

The F_2 plants were classified according to the three above classes. At harvest time the plants were pulled

and threshed separately. The seed from each plant was put into an individual envelope and labeled. The F_2 population consisted of ten segregating lines, each line originating from a single plant.

When two hooded varieties are crossed and an awned character appears in the F_2 generation, there must be a genetic factor or factors in the make-up of the individuals to produce this character. Faust being a hooded selection from Himalaya—an awned barley—and Meloy a hybrid from a cross between Coast, an awned barley, and Nepal, an awnless, then the two barleys Faust and Meloy must carry a character for awnedness in their genetic make-up.

Assuming the imperical formula of the parent Faust to be AAbb and Meloy BBaa, it follows that the new awned type would necessarily be aabb. The characters aabb are recessive awned characters and A and B are dominant hood characters. Whenever a large A or B or both are present the awned factor will not express itself. In the absence of the two hooded factors, the two recessive factors produce the new awned type.

TABLE I

THE RELATIONSHIP OF ROUGH AWNS TO SMOOTH AWNS AND HOODED PLANTS TO AWNED PLANTS IN THE F_2 GENERATION

	Obs.	Calc.	Obs. ratio	Theo. ratio	Dev. from calc.	P. E.	$\frac{\text{Dev.}}{\text{P. E.}}$	Odds
Rough	257	260	2.966	3	3	1.60	1.9	4.00:1
Smooth	90	87	1.034	1	3	1.60	1.9	4.00:1
Hooded	862	907	2.851	3	45	1.96	22.9	999:1
Awned	347	302	1.149	1	45	1.96	22.9	999:1

The data of the F_2 generation in Table I show that for the character hooded-awned the probable error was 1.96 and the odds 999:1. The deviation between the calculated and observed numbers was forty-five. This indicates a very poor Mendelian fit on the basis of 3 hooded to 1 awned. The discrepancy was probably due to the

small number of F_2 progeny. According to the ratio, three hooded to one awned, the hooded segregates were probably AABB, AAbb, BBaa and the awned ones aabb. This indicates a single factor difference for the characters hooded and awned.

The awned characters segregated into both rough and smooth awns. Therefore the smooth-rough genetic formula probably is RR for the lines breeding true to rough, rr for those breeding true to smooth and Rr for the segregating lines. The rough-awned character probably came from the Meloy parent, since one of its ancestors, Coast, was a rough-awned barley.

The data of the F_2 generation in Table I show the deviation between the calculated and the observed numbers to be three. The probable error is 1.6, while the odds are 4.00:1. This indicates an excellent fit to a ratio of 3 rough to 1 smooth awned. Harlan (1920) states a rough- and smooth-awned barley were crossed and the F_2 generation counts showed smoothness to be recessive. He also found that smooth-awned types bred true for smooth-awnedness. The F_2 data show that a ratio of 3 rough to 1 smooth gives the best possible fit. This would indicate that there were one RR, two Rr and one rr type, also that there is a single factor difference for the characters rough to smooth.

Meloy barley is probably a field hybrid resulting from a cross between Nepal, a hooded hull-less barley, and Coast, an awned hulled barley. Faust is a hooded selection from Himalaya, an awned hull-less barley.

The appearance of the awned factor in the F_2 generation from a Meloy-Faust cross was, no doubt, a latent character from both parents expressing itself in the progeny.

The F_2 data show that the characters segregated three hooded to one awned and three rough-awned to one smooth-awned.

The genetic formula of the two parents may be AAbb for Faust and BBaa for Meloy, whereas the hooded seg-

regates may be AABB, AAbb, BBaa and the awned ones aabb.

The genetic formula of the rough- and smooth-awned character may be RR for rough, rr for smooth, and Rr for the segregates.

The F_2 population shows that there probably is a single factor difference between the characters awned and hooded and rough-awned-smooth-awned since they both segregated into 3:1 ratios.

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THE MYTH OF THE LEMUR'S COMB

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THERE is a popular belief among zoologists that the six lower anterior teeth of the lemur constitute a comb structurally adapted for the grooming of the fur (Fig. 1). For over a century, in the literature of comparative

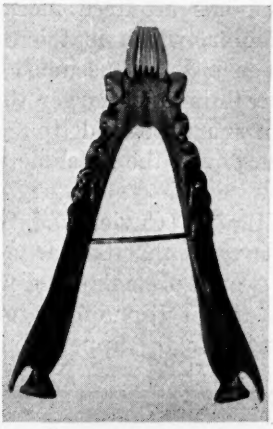

FIG. 1. Lower jaw of *Lemur Catta*. Occlusal view.

anatomy, these procumbent lower anteriors have been cited as a classic example of dental specialization. They have also stimulated interest because of the difficulty in identifying the cuspid and the first premolar in position. Writings on the lemuroid dentition, however, center about the latter question; namely, as to whether the outermost members of the series of the teeth of the comb represent third incisors or modified cuspids. The possibility that these teeth might not be a comb at all has not been suspected.

In the lemur, the six lower anterior teeth extend horizontally forward (Fig. 2). The canine has entered the

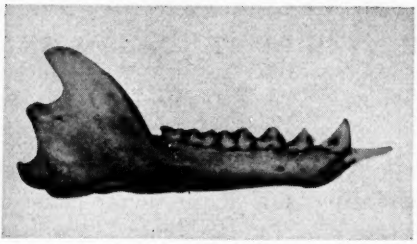

FIG. 2. Lower jaw of *Lemur Catta*. Lateral view.

incisor series and has acquired incisiform characters. The second premolar, which is the tooth immediately posterior to the cuspid, has assumed some caniniform features. This tooth is much larger than the other premolars and has a sharp pointed tip. It bears upon its lingual surface, however, the indelible stamp of the premolar series.

Geoffroy St. Hilaire (Cuvier and St. Hilaire, 1829) was the first to suggest that the large cuspid-like tooth of the lower jaw was a premolar and not a canine. His reasons were that the position of the tooth was posterior rather than anterior to the upper canine (Fig. 3), and

FIG. 3. Skull of *Lemur Catta*. The tooth in the lower jaw immediately posterior to the upper canine is a premolar.

the presence in the young Indrisinae of the milk canine, which is not replaced in the permanent set. Over these dental elements there flared a controversy, the glowing

embers of which have only recently been extinguished. Of the noted contributors to the discussions on the subject were Mosely and Lankester (1868), Grandidier (1876), Flower and Lydekker (1896) and Forsyth Major (1900). In the years to follow accumulating fossil evidence finally proved that the canine had entered the incisor series and that there were only two incisors on either side of the lower jaw. In 1920, W. K. Gregory offered specific paleontological data which led to the general acceptance of St. Hilaire's original contention.

The theory of the comb, on the other hand, could hardly be regarded as a controversial issue. It dates back to Cuvier and St. Hilaire (1829). "These animals are inclined, by their instinct, to naturally scratch themselves with these teeth, which seem to have been given to them only for the purpose of cleaning the fur; for they never use them for either biting or cutting; they form a real comb." Cuvier might well have been the originator of the idea, for he often gave function preference over form in his interpretations of anatomical constructions. The notion of the comb has been handed down from one generation of comparative anatomists to another. A constellation of errors and faulty diagrams which came with the heritage have been uncritically accepted by most modern investigators in the field of primate evolution.

In the following discussion, the quotations from several morphologists illustrate not only the certainty of their statements but also their rationalizations in attempts to find explanations as to just why the lemur needs a hair comb. There is a uniformity of opinion among these authors as to what they understand by "combing the fur." The animal is supposed to employ his dental comb as we use a hair comb. The lower jaw is applied to the fur and the hair is drawn through the fine "parallel teeth" of the comb.

But does the animal actually comb its fur? If so, what accounts for such a remarkable structural adaptation to a function relatively so unimportant to the survival

of the lemur? Or is combing a function only secondary to an already existing organ? If the animal does not comb its fur, what is there about the grooming habit that is so misleading? And what other explanation is there for the peculiar form of the lower incisor teeth? An attempt will be made to answer these questions.

In recent years, Wood Jones has been the chief exponent of the comb theory. In 1918 he wrote:

> It is evident that these lower incisors have some function which is not shared by the upper incisors, for the incisor series of the upper jaw is composed of somewhat rudimentary peg-shaped teeth which are not exercising their full functional rôle. They are not engaging the lower incisors in any action of biting, and in adult skulls they are in an extremely reduced condition. . . . This curious arrangement of the lower incisors and canines is a very striking one, and there can be no question as to its purpose, since these teeth play little or no part in the process of alimentation, but are specialized purely as a hair comb.

He then continues:

> In the case of the Lemur, the application of the hair comb is an oft-repeated business, and one that is very easy to observe in all its details.

In 1925, Wood Jones still described the toilet habits of the lemur with equal certainty. "There is no doubting the anatomical fitness of these lower front teeth for the office of a hair comb; there is no doubting the frequency with which they are put to that use by the Lemur." In 1929, his interpretation continues unchanged. "The anterior teeth of the Lemurs, like the second digit of the pes, have become modified into a highly specialized toilet implement for conducting the toilet of the body fur."

LeGros Clark (1924) has also adopted the comb interpretation. "The upper incisors are shrunken in size, while the lower incisors are very procumbent and styliform. The latter project forwards almost horizontally, and with the modified incisiform canine form a curiously comb-like apparatus which the animals actually use for combing their fur."

R. I. Pocock has an interesting interpretation of these teeth and of the sublingua which he claims is a toothbrush used by the animal to keep the teeth of the comb clean.

In connection with the fur-combing use of the pectiniform mandibular teeth of true Lemurs, it must be remembered that the spatulate finger-tips and short nails of these animals deprive the digits of the scratching power they possess in ordinary mammals with narrow finger-tips and comparatively long claws or nails. Only one digit in the Lemurs is functional as a scratcher, namely, the second of the hind foot, which is short with small terminal pad and long semi-erect claw. Thus is established a most interesting correlation of characters in Lemurs: namely, the uselessness of the fingers for scratching the fur, the modification of the anterior mandibular teeth to subserve that end, and the differentiation of the sublingua to keep these teeth clean from scurf and hair.

Wood Jones (1918), sees a parallel evolution in the structure and function of these teeth:

The dental hair combs of the true Lemurs and the so-called flying Lemurs afford striking examples of parallel evolutions in response to functional demands, for though the end attained is the same in the two cases, the method of making the comb is strangely different. In *Lemur* the incisors and canines are ranged parallel and procumbent like "teeth" of a comb; in *Galeopithecus* the biting edges of the individual incisor teeth have become finely serrated (Fig. 4), and each tooth therefore furnished many "teeth"

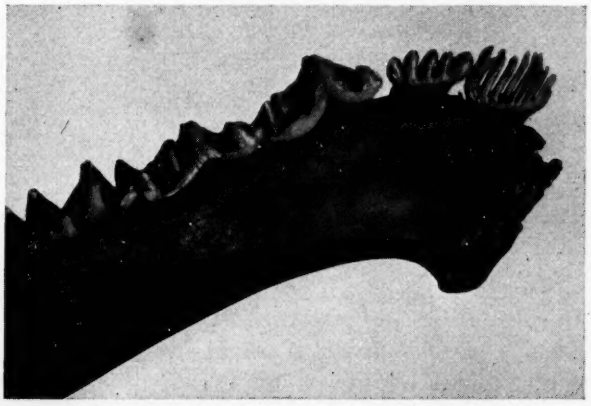

FIG. 4. Left side of mandible of Galeopithecus. Lingual view.

for the comb; this method may be said to constitute an economy of incisors as hair combs, and the canines therefore do not join the incisor series, but on the other hand become modified in the direction of the molar series. These two animal types have developed these dental hair combs probably for the reason that special adaptations have rendered it difficult to perform the toilet of the woolly hair by scratching — the Lemurs having no free claws upon the fingers and only one specialized one on the toes, and the limbs of *Galeopithecus* being hampered by the flying membrane.

When W. K. Gregory (1920) recently discussed the lower anterior teeth of the lemur in his Notharctus monograph he made no mention of the use of these teeth as a comb. He wrote, "In the Lemuridae a profound change of form and function in the lower incisors, canines and P_2 has been conditioned in part by the enlargement of the tongue in adaptation to frugivorous habits." It was not unexpected, of course, when Wood Jones (1929), after writing about fur combs for so many years, referred to Gregory's statement as a "naive conclusion." Then forgetting the story of Aristotle and the number of fly's legs, Wood Jones refuted Gregory's interpretation by pointing out that the hair-combing function of these teeth had been known for a century.

Now there is quite a difference between actual lemur's teeth and those described in literature. Fig. 5 is a re-

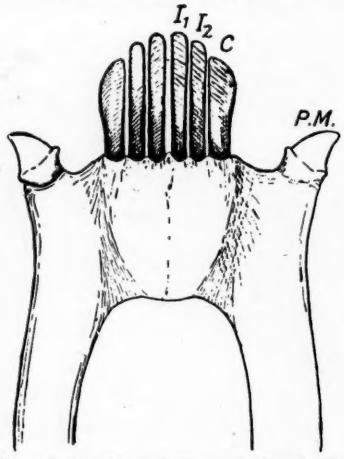

FIG. 5. Wood Jones' drawing of the anterior teeth of *Lemur Catta*, seen from below.

production of such an illustration. It shows the lower anterior teeth well spaced at their tips to permit the passage of hair. On natural specimens, however, it requires considerable pressure to pass the finest waxed thread between these teeth. The contact points are

tight. This holds true for all lemurs, alive, dead and skeletal preparations (Fig. 6). The teeth are not par-

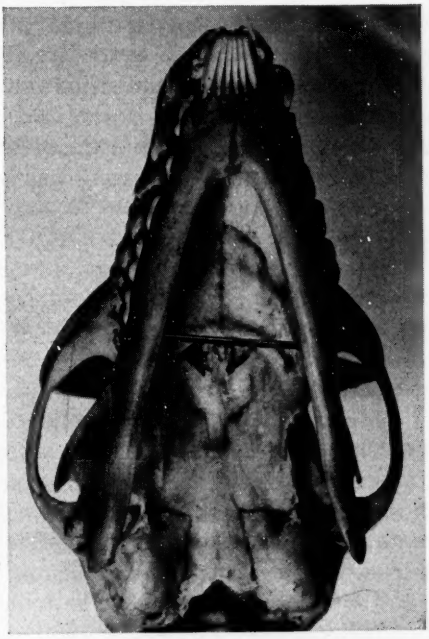

FIG. 6. Skull of *Lemur Catta* seen from below, showing the close contacts of the lower anterior teeth.

allel but converge toward the incisal tips. There is no space between the teeth for about one half the length of the crown. All the space created by their separation near their insertion in the mandible is filled up with gingival tissue. This completely and conclusively rules out the possibility of a comb. Any grooming performed by these teeth must therefore be scratching and not combing. The morphologists claim that these teeth replace the claws. But if Mother Nature, the accommodating genie of the anatomists, was so worried about the sleekness of the lemurs' fur, why turn the claws into flat nails and then go to all the trouble of making a new

scratcher? Nature does this in the same paragraph in which she practices an "economy of incisors."

Now, there is a great probability that the lemurs which Wood Jones observed had acquired a habit of scratching their fur with their teeth while in captivity. But judging from his writings one gets the impression that the lemur spends most of his waking hours in the improvement of his tonsorial elegance. It seems that the amount of time which this animal devotes to grooming has been vastly overestimated.

Through the courtesy and assistance of Dr. Raymond L. Ditmars some studies were made on seven lemurs at the Bronx Park Zoo. Long observation disclosed that in New York they average about forty seconds of grooming to the hour. Eighty-five per cent. of this, however, was performed with the single claw of the hind foot. The balance of the grooming was accomplished by licking the fur with the tongue. These lemurs also do some scratching and nipping with the teeth but not more than any other fur-bearing animal.

Contrary to the opinion of the zoologists, it is not easy to observe what goes on when the lemur applies its muzzle to the fur of its companion. The tongue is agile and quick in action. The fur is thick. The lower anterior teeth are markedly retrusive. Conditions for unbiased observation are most difficult. While working at Bronx Park, three of the lemurs (Catta) met with accidental death. Immediate examination of their oral cavities showed many hairs stuck to the roughened dorsal surface of the tongues. The teeth were clean.

According to reliable observers, lemurs behave differently in their natural habitat. Mr. Richard Archbold, of the American Museum of Natural History, who has hunted lemurs in Madagascar and has carefully observed their habits, has never seen a lemur comb its fur. Several other field workers gave the same report.

The teeth of Lemur and Galeopithecus, the so-called "flying lemur," are supposed to represent a parallel evo-

lution. But Galeopithecus, according to those who have collected this species, doesn't comb its fur either. Nor does the gliding membrane hamper the activities of the limbs in any way. The animal can reach all parts of the fur with its sharp claws. Galeopithecus more likely uses its "comb" for dietary purposes. Mr. Harry C. Raven, on one of his East Indies expeditions, once cut open the stomach of a Galeopithecus immediately after it was caught. The contents consisted of fine slivers of the green bark of twigs, buds and leaves which had been shredded by the "comb" of the lower anterior teeth.

Although the lower anterior teeth of Galeopithecus are finely pectinated, they are also broad, spatulate and procumbent. The upper anteriors have degenerated. In this respect, these arboreal dermoptera resemble the artiodactyls. The anterior teeth of both are adapted to a vegetable diet. There is a better case for parallel evolution between Galeopithecus and the ruminants than there is between Galeopithecus and the lemur.

Wood Jones claims that the upper incisors of the lemur are functionless and do not engage the lower incisors in biting. This may have been true of the specimens with

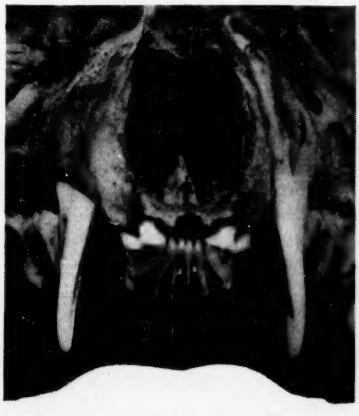

FIG. 7. Muzzle aspect of the articulation of the upper and lower anterior teeth of *Lemur Catta*.

which he worked. But although the crowns are short and small they have a definite specialized form. The roots are comparatively well developed. Figs. 6 and 7 illustrate the fine structural relation between the upper and lower incisors of the lemur. The probability is that the anterior teeth of this animal are adapted to the cutting of leaves and fruit rather than to the combing of the fur.

The myth of the comb is thus exposed in both laboratory and field. An examination of the structure of the skeletal material discloses the utter impossibility of a combing apparatus, and a critical observation of the animal's habits, in my opinion, seals the doom of this century-old myth.

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GENETICS AND ONTOGENY[1]

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PERHAPS the greatest mystery which the experimental embryologist encountered in the early period of his science was the fact that isolated parts of a developing individual could give rise to whole individuals. How it was possible for living wholes to be separated into pieces and to enable the pieces to become wholes of the same kind as the original seemed to be the question of life's nature itself. In a certain way this question has been answered by genetics. If the nucleus of the fertilized egg contains the full set of determiners for the developing whole organism and if there is an equal division of all determiners, so that all cells obtain the full set of them, then the mystery of the isolated parts being able to become equal to the whole ceases to be a mystery.

But here the new problem awaits us. If each cell encloses the same whole group of determiners, how is it possible that in the developing whole that process takes place which is one of the fundamentals of ontogeny, namely, differentiation?

This question is fully justified. To account for differential development in different parts of the embryo we need more than an unchanging set of genes. If the agent, the genes, is unchanged in different parts of the embryo, then the reagent, the plasma, must be diversified. Thus the nature of the non-genic differences between different cells of the developing embryo would be the problem of ontogeny. We know very little about the nature of these differences. To account for their origin it is necessary to assume a diversification of plasmatic regions already in the undivided egg. This enables the division products of the nuclei to segregate into cells with qualitatively or quantitatively different plasmatic content. The result is a primary potential cellular differentiation in spite of the assumed genetic identity. How further differentiation, the production of new differences, not only the cellular segregation of preformed ones, originates can be imagined easily. The position of every part in the diversi-

[1]Introduction to a "Round Table Conference" on "How far Genetics Can Explain Ontogeny," conducted by the Genetics Society of America at the summer meeting in Woods Hole, Mass., August 23, 1935.

fied embryo is specific and different in respect to the surrounding parts, and any physiological activity of a cell or a cell area, if liable to be influenced by the neighboring areas, will lead to new differences. The part of a homogenous area A bordering on another area B will become different from that part of A which borders on C.

This concept of ontogeny has an experimental basis. And although a more definite knowledge is lacking in most cases, we have in the organizer of the amphibian gastrula a source of differentiation the chemical nature of which is being investigated already. But we are far away from the goal of knowing the individual steps which bring about differentiation—and the appearance of an organizing region is itself a process of differentiation. How far does genetics help here? The fundamental contribution of genetics is the proof of the existence of separate units, the genes which play a rôle in the determination of the characteristics of the developing organism. Given the genes, any theory of ontogeny has to attribute to them a place in its developmental scheme. Genes we picture as complicated chemical units, as organic molecules or small groups of them. The part which each individual gene plays in development is thus one of a basic physico-chemical order. Its reaction products with the nearest reacting molecules of its surroundings and their further reaction products interacting with those of other genes directly or indirectly take part in determining those morphogenetic processes which make up ontogeny. How far are we able to express in specific terms this general statement on gene activity during ontogeny? What are the reaction products of genes? What are the interactions of primary gene products? How do they determine ontogenetic processes? We know in a few cases some results of gene activity in chemical terms, even if the final analysis of the chemist has not always been possible, yet pigments and precursors of pigment in crustacea, insects, mammals and in plants, inherited serological properties in vertebrates, reserve carbohydrates in plants are examples in point. The problem of gene activity in these cases offers itself especially clearly as a biochemical one. Given the gene of the constitution (x) and the ontogenetic end-product (y) the problem is one of a chain of reactions which would show how the gene acts. It is clear that an analysis of this chain which begins with the gene is impossible as long as the chemical nature of no single gene is

known. The only knowledge which has a somewhat direct bearing on the action of genes are the deductions as to the so-called position effect and as to the effects of known different quantities of certain genes. The term "position effect" means that the action of a gene has been found to be different if its position in respect to immediate neighboring genes has been changed. Thus the reduction in eye facets in Drosophila which two "Bar" genes cause if located in different chromosomes is less than if they are located adjacent to each other in the same chromosome. No interpretation of this finding, in terms of diffusion of reaction products or of interaction between the neighboring genes or their immediate products, has been given; yet it is obvious that here we come near to the gene itself. As to the effects of different quantities of a gene, we might quote as illustrations that the length of Drosophila bristles has been found in certain limits to increase with the number of "bobbed" genes present or that in corn endosperm the quantity of vitamin A is proportional to the number of "yellow" genes present. But such findings, although again touching on some definite property of gene action, represent at best limiting factors to our interpretation. If one attacks the analysis of the chain of reactions initiated by genes at a point away from the gene, *i.e.*, generally at some end product, one has to follow the chain backwards. This has been done in apparently short reaction chains of which pigments, reserve carbohydrates, etc., are end products of genes. But in no case has the analysis been able to go back to the gene all the way.

Would the problem of the rôle of genes in ontogeny be solved even if we would understand completely some of the just-mentioned reaction chains? In thinking of ontogeny we are not primarily concerned with the last terms of elaboration or deposition of chemical products but with processes of a higher biological order such as segregation of embryonic potencies and morphogenetic happenings.

Although we are convinced of a physico-chemical basis of these processes, their interpretation can be given at present in general terms only. Just as the action of a sterol in inducing a secondary amphibian embryo can be understood only by taking into account the whole, still unanalyzed organic entity of the embryo, so the action of genes in the general processes of ontogeny can be understood only together with a probably very complex background.

What do we know of the rôle of genes in these ontogenetic processes? The method of attacking ontogenetic problems by introduction of the gene concept consists primarily in the comparison of the ontogenies of zygotes which are distinguished by gene differences. It is a study of the same nature as any experimental analysis of ontogeny. But instead of varying some external factors and making deductions as to the nature of ontogeny from their varied effects the numerous gene differences and their combinations afford just as many further analytical tools. It has often been stated that the ontogenetic differences which are determined by the gene differences are not only slight in character but affect also the final terms of ontogeny only. This statement, however, does not hold true. The studies on temperature-effective or other sensitive periods demonstrate that the ontogenetic differences between forms distinguished by simple gene differences can begin very early in development. The gene "Dichaete" in Drosophila has already affected the bristle pattern in early larval stages; some patterns of Petunia flowers are determined days before the bud has grown into a blossom, otocephaly in guinea pigs in its manifold variations is genetically determined in the premedullary stage of embryonic life, and there is also at least one ontogenetic difference based on genic differences which affects the whole ontogeny in a fundamental way, namely, the difference between the two sexes. Such cases indicate that there is no principal distinction in respect to genic determination between early- and late-appearing ontogenetic differences. We thus feel justified in applying any knowledge gained from the study of gene action in the determination of late ontogenetic processes to our interpretation of ontogeny in general. Such knowledge now has led to the concept that genes play a rôle in ontogeny by influencing the velocities of hypothetical reactions which lead to the formation of substances which take part in determination processes. Goldschmidt's work stands in the foreground; and it is significant for the inherent value of his ideas that Plunkett, from a study of very different material, came to nearly identical hypotheses without being acquainted with Goldschmidt's views.

And now let us return to the beginning of our discussion. The genes, we assumed, were present in identical form in all cells of the developing zygote. But ontogeny is characterized by specific, localized processes. If, as pointed out, the immediate or secondary reaction products of genes vary according to their

plasmatic environment, then the fate of different parts of the embryo will be differentially affected—not in spite of identity of genes but just as well if the genes are the same as if they were not.

One further question should be considered here. What is the origin of the primary differences of different egg regions, which we referred to earlier, and what is the relation of their origin to genes, if any? The first part of this question has been discussed by embryologists in terms of polarity and symmetry, related to the position of the growing egg in the ovary, to the point of entrance of the spermatozoon, etc. The second part of the question involves the much more general problem as to the relative rôle of protoplasma and genes in development. In our present discussion we have spoken of genes as *taking part* in the determination of ontogeny and have outlined their general interaction with the surrounding protoplasm. But the relative importance of protoplasm and genes has not been evaluated. Has the protoplasm the ability to differentiate independently of its genes or is it only a raw material indispensable for the genes as the basis for action but of no ontogenetic value by itself? It is doubtful if this question is of real meaning at present. It applies to ontogeny as a whole, and the basis of this whole is the *combination* of plasma and genes. Genes act in their plasmatic surroundings in all stages of ontogeny. This statement contains our general knowledge of the rôles of protoplasm and genes.

The realization that genes are small units the behavior of which in ontogeny has to be studied finally in terms of chemical reactions will guard us against the rudiments of the idea of representative particles. The term "time of action of a gene in ontogeny" seems to contain such a notion. Many genes possibly interact with their surroundings during all stages and, if they are complicated chemical units probably at the same time with different side chains in different ways. This picture of gene activity is derived more from the general gene concept than from actual studies. One might be tempted in its support to quote cases of manifold effects of genes like the following ones: A number of Drosophila genes selected at random, the actions of which we knew only in terms of influence on body pigment or wing shape or eye facet structure, has been found to take part in the determination of a very different character chosen at random, the shape of the female spermatheca; in many higher

plants genes which affect coloration or morphological characteristics of the sporophyte act also on the velocity of growth of the pollen tube; Demerec has shown recently that genes in Drosophila, the action of which we knew only in terms of influence on whole organs, as on eyes or wings, have also a decisive effect on the life of individual cells. But as nowhere we can be sure if we are dealing with effects of different primary gene products or rather with different effects of the same primary product in different surroundings, we must admit that experimental evidence for manifold gene action either at different times in development or at the same time is lacking.

It might seem as if the assumption of continuous action of genes contradicts their assumed rôle in ontogeny, which asks for a *timed* activity. But the timing of specific effects of genes can not be regarded a property of the gene itself but must be looked for in the interaction of the whole developing complex. We might compare the genes with the wheels in the moving belts of an automobile assembly plant, where different parts are appropriately joined together at very definite times. Each wheel in the work "acts" constantly, but the strikingly timed effect is a result of the whole system.

Only loosely connected with this fundamental topic is the question as to the time of action of genes during the cycle from mitosis to mitosis. A visible intake of material into the nucleus occurs during the telophase, while a visible release of material from the nucleus into the protoplasm takes place during the breakdown of the nuclear membrane at the prophase. It has been claimed only recently again that these processes are the visible proofs of gene activity and that the substances released at the prophase contain the gene products which were elaborated during the resting stage and which then take part in differentiation. Although this concept might be true for some cases, we know at least with high probability of some others where the genes affect differentiation during nuclear resting stages. These are cases in which a cell has acquired a new genetic constitution, be it through somatic mutation or segregation, and in which this cell does not divide any more. The supposed gene products released during the last division were elaborated under the old genetic constitution. But as such cells differentiate according to their newly acquired constitution it must be concluded that

their genes have exerted this effect during the resting stage through the nuclear membrane.

Before closing, one more point might be made. Is the assumption of identical genes in all parts of the individual justified? The "proofs" for this assumption are only of indirect nature. It is plausible to assume that the constitution of the genes changes in different parts at definite times and that these changes are reversible in some, non-reversible in other parts. The assumption that the interactions between gene and the plasmatic surroundings result not only in changes of the latter but also in changes of the genes is purely speculative at present. But is it any more speculative than the orthodox one?

If we try to sum up this discussion of how far is genetics able to explain ontogeny, we have to say that genetics has contributed to an understanding of ontogeny by furnishing the gene concept. This concept could be arrived at only by the peculiar methods of Mendelian analysis. But the study of the rôle of genes in ontogeny is a field for developmental physiology. Not that the geneticist will be excluded from the working out of this problem—he will become a genetic experimental embryologist. After a long journey which took him sometimes out of sight of his fellow biologists, he returns home again with some new concepts and tools.

PAPERS READ AT RECENT MEETINGS OF THE GENETICS SOCIETY OF AMERICA[1]

PROFESSOR P. W. WHITING
SECRETARY

ABEGG, F. A., and F. V. OWEN, U. S. Bureau of Plant Industry: *A Genetic Factor for the Annual Habit in Beets (Beta vulgaris, L.) and Linkage Relationship.* Munerati has shown that the annual habit in beets is dominant and controlled by a simple Mendelian factor. Crosses made by the authors with one of Munerati's extremely annual selections have corroborated this result. In addition, a linkage was found between *B*, the factor for annual habit, and *R*, a red crown color factor. The crossing-over value between *B* and *R* is approximately 16 per cent. Further studies with a non-annual type, which, however, bolted readily under special conditions, showed that a single factor again seemed to be responsible for bolting. The same linkage with the *R* color factor was also demonstrated. One major bolting factor is apparently necessary, but its expression is dependent upon other modifiers, with environmental conditions playing an important rôle.

ABEGG, F. A., and F. V. OWEN, U. S. Bureau of Plant Industry: *A Genetic Factor for Curly-top Disease Resistance in Beets, (Beta vulgaris, L.) and Linkage Relationships.* Resistance of beets to the curly-top disease is conditioned by a partially dominant factor *C*. Groups of plants resembling the resistant and susceptible parental strains were recovered in F_2. The postulation of the *C* factor is strongly dependent on a linkage with the crown color factor *R*. Red and white F_2 classes differed significantly in both foliage symptoms and root weights. F_3 data support the existence of the *R–C* linkage. The crossover value is estimated to be between 20 to 30 per cent. Recently the *C* factor also has been found associated with resistant selections from the U. S. No. 1 variety, and hence it is of economic importance. Here the *R–C* linkage has also been demonstrated.

AVERY, A. G., and A. F. BLAKESLEE, Carnegie Institution of Washington: *Visible Mutations from Aged Seeds.* In the progeny

[1] The abstracts of papers presented at Woods Hole, St. Louis and Princeton meetings are arranged in alphabetical order according to the name of the senior author.

of 315 plants grown from seeds which had been aged from 7 to 10 years a total of 11 new visible types due to mutation have been secured. This is a rate of 3.5 per cent. "visible mutations." In the progeny of untreated normal parents during the last 20 years of *Datura* breeding work only 7 "visible mutations" have been found. It would be very difficult to calculate the rate of mutation in these controls, but it must be extremely low. In the same 315 plants, a total of 30 pollen abortion types, a rate of 9.5 per cent., had been obtained by Dr. Cartledge in earlier tests. The mutations from aging seeds, which show as visible morphological effects, are thus about one-third as frequent as those which cause pollen abortion.

BAUER, HANS: *The Structure of the Salivary Gland Chromosomes in Chironomidae.* The chromosomes are composed of thin chromonemata, carrying in corresponding positions completely staining dotlike euchromomeres. The chromonemata form a solid bundle, no sign of a core substance being present. By the union of the homologous chromomeres the disk-like aggregate chromomeres are formed. The different broadness of these "bands" is caused by two or more single disks lying very near together. The dotted "bands" result from incomplete union of the smallest euchromomeres. The number of chromonemata is approximately 100 in *Chironomus Thummi* and 350 to 400 in the very big chromosomes of *Cryptochironomus defectus.* Thinner chromosomes have a smaller number. It follows from this that the divisions of the chromonemata need not be simultaneous. In most cases the two homologus chromosomes are completely paired. In some species certain regions of some chromosomes show lack of pairing. The chromosomes of *Trichotanypus* are only loosely coiled. Heterochromatic regions are characterized by heterochromomeres, which consist of a non-staining center and a chromatic surface. Like the euchromomeres, they are integral parts of the chromonemata, and not accessory material. The heterochromatic regions may contain one or more heterochromomere disks. In the latter case in some chromosomes no regular disks are formed, the ends appearing aster-like. In spite of the possession of heterochromatin the chromosomes are not connected (as in *Drosophila*) in *Glyptotendipes* and *Trichotanypus.* In *Prodiamesa olivacea* 3 chromosomes are united terminally, a fourth lying free, though it contains heterochromatin. Inversions and other rearrangements are found to be very wide-spread.

BEADLE, G. W., and EPHRUSSI, BORIS, California Institute of Technology and Institut de Biologie physico-chimique, Paris: *Transplantation of Drosophila.* A technic of transplantation applicable to *Drosophila* has been developed. With this technique, consisting of injection by means of a micro-pipette, ovaries, as well as eye, antennal, leg and wing imaginal disks have been successfully transplanted. Implanted ovaries develop normally. Breeding tests show that they often establish functional connections with the genital ducts. Implants of *D. simulans* ovaries in *D. melanogaster* are able to develop and establish functional connections. Interspecific transplants of *D. funebris* eye disks in *D. melanogaster* have been successful. Preliminary studies on the intraspecific transplantation behavior of most of the eye color mutants of *D. melanogaster* have been made. In most cases, eye disk implants show autonomous development of pigment. Vermilion (previously studied by Sturtevant in mosaics) and cinnabar eye transplants show non-autonomous pigment development under certain genetic conditions, autonomous under others. A study of these and other cases leads to certain conclusions concerning the nature of the host-implant influences involved. Studies of Bar eye disk implants in vermilion hosts suggest that the rates of one or more developmental processes in the eye, relative to those of other parts of the organism, influence the reactions concerned with eye pigmentation. This is supported by studies of cases in which host and implant are at different stages of development at the time of transplantation. The time at which the vermilion character becomes irreversibly determined, *i.e.*, can not be modified by transplantation, is relatively late in development—only a few hours before pigment formation is visibly apparent.

BENNETT, L. S., West Virginia University: *Studies on the Inheritance of Resistance to Wilt Fusarium niveum (E. F. S.) in Watermelons.* Crosses were made between the Commercial Early Fordhook watermelon, which was susceptible, and an inedible Russian variety, which was resistant. Resistance was determined by greenhouse tests in wilt-infested soil, using three physiologic forms of the organism in separate concurrent tests. The F_1 was intermediate in its reaction. There was definite evidence of segregation of factors for resistance in F_3 families and in families from backcrosses to both parents, but simple mendelian ratios were not apparent. Low correlations were obtained between the reactions

to the three *Fusarium* forms which may indicate different factors for resistance to the different forms. There was no evidence of close linkage between resistance and several morphological characters, although the desirable qualities, except for resistance, appear to be recessive and governed by many factors. The selection which has been made following the inheritance study has demonstrated the possibility of combining resistance with other desirable qualities. The chromosome number of the Russian was found to be eleven pairs, the same as in Fordhook.

BERGNER, A. D., CARTLEDGE, J. L., SATINA, S., and A. F. BLAKESLEE, Carnegie Institution of Washington: *A Gene for Compound Pollen Grains in Datura.* This gene causes the abortion of about 80 per cent. of the pollen grains. Among the "good grains" there are a varying number of compound grains, often curiously misshapen as a result of partial failure of cytokinesis. Two, three or four grains may be held together by small protoplasmic connection and a single grain may have two nuclei. There may be only a suggestion of furrowing in a large spheroidal or ellipsoidal grain. Such grains contain either several n-sized nuclei or a large unreduced nucleus. Examination of pollen mother cells has shown that both the first and second meiotic divisions take place although detachment of one or two chromosomes is rather common (about 10 per cent.). In *Datura* cytokinesis is simultaneous. The gene "compound" affects cytokinesis so that tetrads of microspores separate late from the pollen mother cell, even when no cytoplasmic connections hold them together. Cytoplasm is somewhat unevenly divided among the four members of a tetrad. Only a superficial examination of megasporogenesis has been made, but both meiotic divisions have been found to occur. Since plants homozygous for this gene have been obtained the conclusion is reached that some of the pollen grains which carry this gene do not abort but produce functional gametes.

BOGART, RALPH, and HEMAN L. IBSEN, Kansas State College: *The Distribution of Black and Red Pigment in Cattle Hairs.* Only black and red pigments are found, the former in irregular, opaque clumps, the latter in a homogeneous, translucent condition, diffused through the hair. In *B* (Ibsen, 1933) animals the black is very closely packed. By bleaching the black clumps, making them

transparent, red (*R*) is found to be present. *Bs* hairs show red without bleaching the black, since the black clumps are less closely packed. Red hairs (*R/R b/b bs/bs*) also carry some black clumps. These are found thinly scattered both in the medulla and in the cortex, the amount in the cortex determining to a large extent the intensity of the red. White hairs from *s/s, N/N* and albino animals all show some black clumps in the medulla, thus rounding out proof for the conclusion that black pigment is present in all cattle hairs. These same hairs carry no red pigment. Extremely dilute red hairs are found to have the red pigment in a dilute condition. Therefore variation in intensity in red is due to two causes. This probably accounts for the greater variation in red as compared with black. All the black pigment examined thus far seems uniform in intensity. No hairs from duns have been investigated, however. All cattle examined, except albinos, have red present in at least some of the hairs. Since black is present in all hairs, one is forced to conclude that *B, Bs* and *Ps* are all due to different modifiers acting on the "fundamental" gene for black, present in the homozygous condition in all animals.

BOSTIAN, C. H., North Carolina State College: *Fecundity of Triploid Females in Habrobracon juglandis.* In the wasp *Habrobracon* around 90 per cent. of diploid males are entirely sterile. Of 359 males tested all were sterile except 19 which produced from one to six daughters each, demonstrating a very slight degree of the fertility shown by normal haploid males. Triploid females (3N = 30), the daughters of diploid males, give rise to very few adult offspring. Eggs were counted and their development observed for 34 triploid females. Of 2,023 eggs laid, 32 became larvae, 12 pupae and 8 adults (2♂, 6♀). In contrast, 17 diploid females laid 4,790 eggs, of which 3,884 became larvae, 3,789 pupae and 3,491 adults. Egg production for triploid females, averaging 5.4 eggs per female per day, was about one fourth that of normal diploid females. Hatchability of eggs and production of adult offspring were, respectively, 1/50 and 1/800 that of diploid females. These results agree closely with previous reports. A. R. Whiting found 75 per cent. of diploid males entirely sterile, and reported that 4 triploid females laid 221 eggs, 5.5 per female per day, of which 8 became larvae and none adults. M. M. Torvik tested 223 diploid males, finding 90 per cent. entirely sterile, and obtained 9 adults from 77 triploid females. No correlation has

been found between the sterility and gross internal anatomy of triploid females, which would explain their low production of eggs. The failure of most eggs to hatch was probably due to their having received unbalanced sets of chromosomes.

BRIDGES, CALVIN B., Carnegie Institution of Washington; California Institute of Technology: *Demonstrations (1) of the first translocation in Drosophila melanogaster and (2) of normal repeats in chromosomes.* Salivary gland nucleus of female of the "Pale-translocation" race homozygous for the translocated duplication (Def (2) Pale/Curly; Dup (2–3) Pale/Dup (2–3) Pale) shows extent of non-reciprocal non-terminal deficiency near end of 2 R, and identical extent of this segment intercalated (in reversed direction) into the middle of 3 R. Three-stranded "synapsis" of the normal 2 R end with the homozygous duplication illustrates the high specific attraction of homologous genes, whereby this tiny section of 2 R succeeds in finding and fusing with its distantly situated hormolog in spite of having to drag along the rest of 2 R. Salivary gland nucleus with wild-type left limb of chromosome 2, showing extensive sections of homologous bands in two positions simultaneously. From this it is inferred that the evolution of the normal chromosome and the increase in number of genes has been accomplished by the method of "duplication" of previously existing genes, presumably followed by diversifying genic mutation.

BRITTINGHAM, WILLIAM H., Princeton University: *Oenothera franciscana mut. tenuifolia, a Gene Mutation Induced by Radium Treatment.* A weak, deformed plant strikingly altered in all characters and completely pollen sterile appeared in the progeny of a plant of typical *Oe. franciscana* whose young buds had been exposed to radon (radium emanation). A cross between this unusual plant and normal control *franciscana* gave, in the second generation, some families which segregated in a 3:1 ratio for the new leaf trait here reported, and other families which did not segregate, indicating that both heterozygotes and homozygotes were present in the F_1 of the cross. The most conspicuous feature of the new form, mut. *tenuifolia,* is its extremely narrow leaf blade. The rosette leaves are about one fourth the width of rosette leaves of *franciscana.* Additional features of the new mutant are a somewhat slower growth and a slightly modified

mature habit. Mut. *tenuifolia* has bred true for three generations. Breeding data show very close 3:1 ratios on the selfing of heterozygotes, excellent 1:1 backcross ratios and a 1:2 ratio of homozygotes to heterozygotes among the normal plants of segregating populations. In reduction division both *franciscana* and mut. *tenuifolia* show seven pairs of chromosomes. Mut. *tenuifolia* is the first demonstrated gene mutation in this strain of homozygous pure-breeding *Oe. franciscana*. It is also the first gene mutation to be experimentally produced in *Oenothera*.

BRITTINGHAM, W. H., and GEORGE H. SHULL, Princeton University: *The Induction of Triploidy through Hybridization. Oenothera Lamarckiana* and *Oe. franciscana* are in the subgenus Onagra and *Oe. Drummondii* in the subgenus Raimannia. Three crosses, in which *Oe. Drummondii* pollen has been applied to *Oe. Lamarckiana*, to typical *Oe. franciscana* and to a narrow-leafed mutant of the latter species secured after treatment with radon, have in each case given either wholly triploid progeny or a mixture made up predominantly of vigorous full-green triploids and a less numerous weak yellow-green or lutescens-like biotype. It can not be assumed reasonably that these triploids have resulted from omission of meiosis either in the egg-parent or the pollen parent. It is assumed that they have resulted (a) through double fertilization of the egg, or (b) by the production of an embryo from the primary endosperm nucleus. We are hoping to be able to determine by further investigations which of these two suggested methods has been followed.

BUCHHOLZ, J. T., and A. F. BLAKESLEE, University of Illinois and Carnegie Institution of Washington: *Genes Affecting Pollen-tube Growth in Datura.* Six genes affecting pollen tube growth and for which the pollen tube abnormalities are microscopically demonstrable have been studied intensively over a period of seven years, through from 4 to 7 successive generations. One class is transmitted maternally only to half of the progeny, the other class is transmitted maternally and may also be pollen transmitted under favorable conditions. All these abnormalities have been studied for their effects on the segregation of other genes. They seem to fulfil the conditions of genes in every respect and may be assigned to definite loci on chromosomes. Two of them, *sb–2* on the 17 · 18 chromosome, and *s–2* on the 13 · 14 chromosome

have shown consistent linkage relations with other genes on these chromosomes. The former has given 23%, 33% and 35% crossing over with other genes on the 17 · 18 chromosome and is located at or near the · 18 end of this chromosome, while *s–2* has shown linkage with an albino gene on the 13 · 14 chromosome with 32% crossing over. The genes demonstrated show distinctive differences in microscopic preparations. The methods used in their localization, as well as the genetic effects produced by them in the segregation of other genes, may be demonstrated. Demonstrations of pollen-tube growth in interspecific pollinations will also be available.

CARTLEDGE, J. L., L. C. BARTON and A. F. BLAKESLEE, Carnegie Institution of Washington and Boyce Thompson Institute: *Temperature as a Factor in the Increased Mutation Rate.* Increased mutation rates have been obtained in Datura by radiation treatments and by the more nearly natural processes of aging seeds and pollen cells. Either recessive gene mutations or pollen lethals may be used as an index to the mutation rate. The effects of temperature, as one of the factors involved in the production of mutations under more natural conditions, have been investigated. About 5 per cent. mutations were obtained, using the pollen lethal index, from seeds held at 5 per cent. moisture level and subjected to a temperature of 75° C. for from 24 to 28 hours. A similar rate of mutation was obtained in 18 hours' treatment at the same temperature but using seeds with 7.5 per cent. moisture content. With the moisture at 5 per cent., but with temperature at 80° C., 14 to 16 hours' treatment gave about the same mutation rate. No mutations were found in the unheated controls. Thus high temperatures induce mutations of the same sort, but at a lower rate than the harsher radiation treatments or than the more effective natural aging processes. The susceptibility of the cells to the temperature effects which bring about mutation is to some extent dependent upon the moisture content. Age of the cells, if not itself a cause of mutation, must increase their susceptibility to the factors in nature, such as heat, which are effective in producing mutative changes.

CHILD, GEORGE, Amherst College: *The Effect of Starvation on the Mean Bristle Numbers of sc–1 in Drosophila melanogaster.* A large number of larvae were allowed to develop in unyeasted

bottles at constant temperature. As the larvae pupated they were removed at 12-hour intervals to agar slants. The time of development was increased by as much as five days. The mean bristle numbers (M) of the various bristles affected by *sc–1* behave differently with increasing time of development. The M asc, psc and pv increase and the M mor decreases with increasing time of development. The M oc appears to increase rather sharply and then decreases slightly. The M anp is apparently unaffected. The left-right correlation coefficients of the various bristles are positive and significant, showing the non-uniformity of the environment for the entire population. When each group pupating in a twelve-hour period is considered separately, however, the l. r. correlation coefficients are smaller and in many instances not significant, thus indicating that, for these groups, the environment is fairly uniform.

CHILD, GEORGE, Amherst College: *The Effect of Temperature on the Mean Bristle Numbers of sc–1, sc–5 and Their Compound in Drosophila melanogaster.* An isogenic *y sc–5* stock was established by back-crossing *y sc–5/sc–1* into an inbred *sc–1* stock for seventeen generations. The mean bristle numbers of *sc–1, y sc–5* and *y sc–5/sc–1* were determined through a temperature range from 14° to 30°. The mean bristle numbers (of those bristles affected by temperature) of *y sc–5/sc–1* lie between *sc–1* and *y sc–5* at all temperatures. With the exception of the i. v., the values for the bristles of *y sc–5* are higher than those of *sc–1.* The *oc,* which are never affected in *y sc–5,* are affected in the compound *y sc–5/sc–1.* During the experiment one cross-over was obtained between *y* and *sc–5.* The mean bristle numbers of *sc–5* and *y sc–5* were found to be the same.

CLELAND, RALPH E., and B. L. HAMMOND, Goucher College: *Chromosome Configurations in Some New Oenotheras.* A number of forms, probably representing races of *hookeri, irrigua, rydbergii* and *macrosiphon,* were collected by Dr. P. A. Munz, and grown by the authors. Chromosome configurations of these strains are presented and demonstrated. The configurations in a few hybrids of the peculiar eastern type *argillicola* are also announced, and suggestions made with respect to the affinities of this race.

COLLINS, J. L., and K. R. KERNS, University of Hawaii: *Origin and Nature of Tetraploid Pineapples.* The diploid chromosome number in the pineapple is 50. Triploid plants having 75 chromosomes have also been reported, but this is the first account of tetraploid pineapples. Tetraploids have been obtained from two methods of origin. The first tetraploids, nine in number, were the total progeny obtained by pollinating diploid Cayenne plants with pollen from a triploid hybrid. It is believed that these 100-chromosome plants originated through the fertilization of normal 25-chromosome egg gametes from the diploid with non-reduced pollen gametes from the triploid containing 75-chromosomes. Since both parents were heterozygous each of the nine tetraploids represent genetically different forms. The second group of tetraploids consisted of five plants, all the vegetative progeny of a single hybrid plant. This parent plant was one of a population of plants resulting from crossing the two pineapple varieties, Pernambuco and Monte Lirio. There are two probable processes by which this tetraploid could have originated—the union of two diploid gametes or the doubling of the chromosome number in the zygote following fertilization. It has not been possible to ascertain which was operative in this case. These pineapple tetraploids show the increased size of cells and organs common to such forms. The percentage of good pollen in the tetraploids is approximately equal to that of the diploids. Triploids on the other hand have a very high percentage of undeveloped pollen. The tetraploids appear to be self-incompatible. Crosses with diploids gave no seed when used as the pistillate parent but gave viable seed when used as the pollen parent. The amount of seed produced by using pollen from the tetraploid on diploid plants varied with different pistillate plants. The majority of pineapple varieties are self-incompatible and cross-compatible. This fact must be taken into account when discussing the fertility of the tetraploids.

CURTIS, M. R., W. F. DUNNING, and F. D. BULLOCK, Columbia University: *A Study of the Influence of the Genetic Constitution of the Host on the Growth of Cysticercus Sarcoma 146 and the Jensen Rat Sarcoma.* Simultaneous inoculations of *Cysticercus* sarcoma 146 and the Jensen rat sarcoma into 1,123 rats of the Zimmerman 61 strain and 1,507 of the Marshall 520 strain showed that the former strain was 96 per cent. positive for 146 and 96

per cent. negative to JRS and the latter strain was 50 per cent. positive for 146 and 93 per cent. positive for JRS. The F_1 hybrids were 98 per cent. positive for 146 and 93 per cent. positive for JRS. The progeny of the hybrids back-crossed to the Marshall 520 strain were 75 per cent. positive for 146 and 91 per cent. positive for JRS and back-crossed to the Zimmerman 61 strain were 96 per cent. positive for 146 and 36 per cent. positive for JRS. The Zimmerman 61 strain seemed to be practically homozygous for a dominant factor which determined a physiological constitution favorable for the growth of 146 and the Marshall 520 strain was heterozygous for this factor and practically homozygous for another dominant factor which determined susceptibility to JRS. There was no appreciable difference in the rate of growth of either tumor in the heterozygous hybrids and in the homozygous parental strains.

DANFORTH, C. H., Stanford University: *Genetics of Sex Differences in Plumage (Syrmaticus reevesi).* Analysis of the plumage pattern in Reeves pheasants has been attempted by means of skin transplantation, supplemented by gonadectomy and by hormonal injections. Results of the experiments indicate that with reference to sex hormones the males and females react much like two different species. This sex difference in response to the same hormones is apparent in feathers of several parts of the body. As may be seen in the demonstrations, there are four fundamental types which are quite distinct from each other in tone and markings. These correspond to (1) male genotype and male hormones, (2) male genotype and female hormones, (3) female genotype and male hormones and (4) female genotype and female hormones. Analysis of the entire plumage has not been completed, but there is evidence that, as in true species, differences are more marked in some regions than in others. So far as pertinent data are available they indicate that the critical genes are in sex chromosomes rather than in autosomes. The female form of the male feather and the male form of the female feather is each suggestive in some measure of feathers found in other species. The marked lack of equivalence in feather-bearing skin of male and female Reeves pheasants is in contrast to the close similarity in reactivity of the two sexes in the related ring-necked pheasant and domestic fowl. The situation in Syrmaticus might be due to a gene in the W chromosome or to a differential effect of Wz and ZZ complexes.

DAVENPORT, C. B., Carnegie Institution of Washington: *Theory of Gene Action.* Fig. 1. Drawing of metabolic nucleus in a human glandular cell. From Maximov-Bloom. Note: The deeply stained particles on nuclear membrane; the concentration of material around the nucleus; the formed droplets of secretion stored at the lumen end of the cells; the increasing size of these droplets from near the nucleus to the center of the cell, suggesting their origin at the nucleus. Fig. 2. Drawing showing position of stained particles (chromidia?) as seen in optical section of spermatocyte, first order, of a spider. From Sokolow, 1934, *Zeit. f. Zellforsch.* 21: 1. Fig. 3. Position of stained particles (chromidia?) on nuclear membrane in spermatocyte spider cell, surface view. From Sokolow, 1934. Fig. 4. Position of chromidia (?) in *Councilmania.* From Kofoid, Swezy and Kessel, 1924. Fig. 5. Schema of interaction between gene and substrate, indicating the production of molecules to constitute the cell wall, and also production of metabolic molecules preparing for the next stage in cell development. The chemical processes going on at one stage prepare the chemical reactions for the next stage, and thus determine the time and place of successive stages in ontogenesis.

DEMEREC, M., and MARGARET E. HOOVER, Carnegie Institution of Washington: *Deficiencies in the Forked Region of the X-Chromosome of Drosophila Melanogaster.* Out of a number of deficiencies affecting the forked region of the X-chromosome, which are now available in our laboratory, two are selected to demonstrate salivary chromosome figures of (1) a two-band deficiency, (2) a deficiency including these bands and several others. The two-band deficiency affects the bands designated by C. B. Bridges as 15 F 1 and 2. Genetically, this deficiency involves the forked locus only, indicating that the forked locus is represented by either the 15 F 1 or 15 F 2 band. The second deficiency affects 13 bands, *viz.*, bands 15 E 2 to 16 B 7. Genetically, this deficiency covers the forked and bar loci. It does not include M–o locus, indicating that the position of this locus is not between forked and bar (as it has been previously assumed).

DOBZHANSKY, TH., and C. C. TAN, California Institute of Technology: *A Comparative Study of the Chromosome Structure in Two Related Species, Drosophila pseudoobscura and D. miranda.*

In the oogonial or nerve cell metaphase plates the chromosome complement of the females of *D. pseudoobscura* appears identical with that of *D. miranda.* If the chromosomes are studied in the salivary gland cells of the hybrid larvae this identity proves to be deceiving, since no chromosome of pseudoobscura has the same arrangement of bands as any of miranda. In the hybrids the chromosomes mostly fail to show the intimate pairing which is so characteristic for the salivary gland chromosomes of either pure species. Nevertheless, by selecting cells in which some pairing has taken place, it is possible to determine what kind of rearrangements in the chromosome apparatus have occurred. These prove to be mainly inversions and intrachromosomal translocations; interchromosomal changes are much less frequent, although some are observed. Inverted and translocated sections vary greatly in length; some of them involve only a few bands. The right limbs of the X-chromosome are most similar in the two species; they differ only in one rather extensive inversion and perhaps some minor changes. The second chromosomes (the Bare-Smoky linkage group) are already somewhat more different; the left limbs of the X-chromosome come next. In the third (the orange-purple linkage group) and the fourth (Curly linkage group) chromosomes the rearrangements are so profound that their precise nature has been determined only incompletely. The small fifth chromosomes are similar at their bases; the rest of the banding is different. The contention of many investigators, according to which chromosomes of related species may be greatly different in the gene alignment, is proven at least in the case of *D. pseudoobscura* and *miranda.* On the other hand, our results show how insecure may be the conclusion frequently made by cytologists who infer from the similarities of the metaphase chromosomes that the genic content of these chromosomes is also similar.

EDMONDS, HENRY W., and PAUL B. SAWIN, Washington University and Brown University, Providence: *Variation of the Branches of the Aortic Arch in Rabbits.* Post-mortem examination of the aortic arch in 1,900 rabbits of known pedigree has revealed variants from the usual pattern of branching (designated as type A). These are classifiable into 14 other types or subtypes, of which the two most common (arbitrarily designated as types B and E) occur with respective incidences of 18 per

cent. and 1 per cent. Types B and E differ from type A in respect to origin of the right subclavian artery and display both a familial occurrence and a relatively higher incidence in certain inbred strains, indicating the probable hereditary nature of type differences. Segregation ratios obtained for types A, B and E are consonant with a difactorial Mendelian hypothesis, although critical data are not yet available. Attention is drawn to the existence of comparable variation in man.

EYSTER, WILLIAM H., Bucknell University: *Inheritance of Doubleness in Tropaeolum majus.* Doubleness in the flowers of *Tropaeolum majus* involves an increase in the number of carpels, stamens and petals so that the total number of floral parts is increased from 21 to a maximum of 33 in double flowers and to approximately 135 in super-double flowers. In the super-double flowers the essential organs are greatly proliferated and modified into almost completely sterile petaloid structures. The genes for super-doubleness, singleness and doubleness constitute a series of alleles with dominance in the order given.

EYSTER, WILLIAM H.: *Revised Linkage Maps of Chromosomes 5 and 9 in Maize.* Approximate loci are given of more than 30 genes in chromosome 9 and approximately 20 genes in chromosome 5 in maize.

EYSTER, WILLIAM H., and H. CLYDE EYSTER: *Genetic Variations in a Commercial Field of Maize.* From material taken from a single field of commercially grown maize have already been found 11 kinds of seedling characters, 6 kinds of kernel characters, 12 types of leaf characters, 2 kinds of culm characters, 2 kinds of ear characters and 2 types of tassel characters.

EYSTER, WILLIAM H., and BURR A. ROBINSON: *Genetic Studies of Tropaeolum.* Yellow foliage is recessive to green, primrose flower color is recessive to golden and the anthocyanin colors are more or less epistatic over the plastid colors. In anthocyanin colors, dominance varies with depth of pigmentation. Genes for yellow foliage and dark maroon flower color are in the same chromosome. The number of floral parts are determined by three known genes which form a series of triple alleles.

EYSTER, WILLIAM H., and BURR A. ROBINSON: *Gametophytic Genes in Relation to Modified Ratios.* Gametophytic genes in chromosome 9 cause wide modifications in the phenotypic ratios of characters having their loci in this chromosome. The loci and effects of the gametophytic genes concerned are given.

GOODALE, H. D., Mount Hope Farm: *Has Selection Creative Power?* Charles Darwin and his earlier followers attributed creative powers to selection, but, since Johannsen, the view has gained general acceptance among geneticists that selection creates no new inheritance but merely rearranges the old. Recently, it has been possible to create a character new to the strain in which it occurs by selection in the Darwinian manner. It began in a single individual with a spontaneous but minute departure from the normal. An almost invisible white spot on the head of a self-colored mouse has grown until it covers more than half the face. An explanation of this experiment, those of Lutz, '11, and that of Payne, '18, based on accumulation of favorable multiple genes, is difficult to reconcile with the restricted variability of early generations, limited heterozygosity resulting from five or less—Lutz and Payne began with a single pair—related ancestral individuals and continuous inbreeding. An explanation based on successive point mutations requires supplementary explanations to account for their frequency and orderly sequence in the direction of selection, and is after all only a restatement in new terminology of Darwin's belief. All other explanations based on current genetic knowledge or theory are more or less unsatisfactory. If the work on salivary chromosomes can be correctly interpreted to mean that genes, as now known, are only part of the chromosome mechanism, the ability of selection to create something new may eventually be associated with other parts of the chromosomes.

GORDON, MYRON, Cornell University: *The Production of Spontaneous Melanotic Neoplasms with a Single Type of Melanophore in Hybrid Fishes.* The Mexican platyfish, *Platypoecilus maculatus,* has two types of melanophores: micromelanophores, controlled by an autosomal dominant factor *St;* macromelanophores, controlled by a sex-linked dominant factor *Sp.* The Mexican swordtail, *Xiphophorus hellerii,* generally has micromelanophores. Recently a non-micromelanophoric type, *st st,* has been developed

and it has proven to be recessive to the normal type with micromelanophores, *St St*. Heretofore only the micromelanophore type of swordtail, *St St*, were available for hybrid crosses with the spotted platyfish, *Sp Sp*. These crosses resulted in the development of melanotic neoplasms in hybrids. The neoplasms contained both types of melanophores. By using the recessive golden swordtail, *st st sp sp* and the spotted platyfish, recessive for micromelanophores, but dominant for macromelanophores, *st st Sp Sp* or *st st Sp sp*, hybrids were produced with but one type of melanophore—*macromelanophores*. These hybrids nevertheless developed melanotic neoplasms. Hybrids having micromelanophores only, or no melanophores at all, are not melanotic and do not develop melanotic neoplasms.

GORDON, MYRON, Cornell University: *The Production of Spontaneous Melanotic Neoplasms at Birth in Hybrid Fishes.* When black spotted *Sp* platyfish, *Platypoecilus maculatus*, are crossed with swordtails, *Xiphophorus hellerii*, the hybrids develop melanotic tumors which generally become neoplastic in middle or past middle life, 6 to 12 months. By a series of backcrosses of the melanotic adult hybrids to *Xiphophorus* many fishes were obtained which showed definite melanotic neoplasms at birth. Those melanotic hybrids which were not born with neoplasms soon developed them. The death rate of the melanotic hybrids as compared with their normal mates is significantly higher. These fishes are viviparous. The gestation period is thirty days. It is assumed that in some individuals melanotic neoplasms develop in embryonic life.

GOWEN, JOHN W., Rockefeller Institute for Medical Research: *On the Quantitative Aspects of Disease.* Genetics, by preference, deals with characters which are sharply contrasting and dependent on single gene differences. In plants instances are known where host susceptibility or resistance to specific pathogens conforms to these requirements. Animals are less fortunate, since only one disease, the liver disease of mice due to *B. piliformis*, is known to be dependent on a single gene pair. For other diseases the character, host resistance, must be estimated from the morbidity and mortality statistics. The paper to be presented provides a method for deriving the resistance curve from such statistics and for the utilization of its perimeters in inheritance studies on disease.

HARNLY, MORRIS H., New York University: *The Pennant and Pennant/Vestigial Phenotypic Response to Temperature.* Pennant is a new regressive mutation of the vestigial gene to a recessive wild-type allelomorph. Homozygous pennant is phenotypically wild-type throughout the temperature range of 16° to 30° C., and at each temperature examined the size of the wings is practically the same as that of the wild-type allelomorph at the same temperature. The size of the wings of the pennant genotype varies inversely with the temperature, as do those of the normal allelomorph. The lethal temperature of pennant is 1° below that of its allelomorph vestigial and 2° below that of the normal allelomorph. The pennant/vestigial heterozygote has intermediate strap-like wings at 25°. From 16° to 22° the wing size of the heterozygote varies inversely with the temperature; from 22° to 26° there is no change in wing size; and from 26° to 32° the wing size varies directly with the temperature and the phenotype progresses from strap through the allelomorphs antlered, Snipped, Carved and notched. The data demonstrate conclusively: (1) that the effects of the pennant and vestigial genes are not summations in the heterozygote nor are they independent of each other; (2) that the vestigial gene does not have an inhibitory action; (3) that the effects of the gene on the amount of materials produced and their organization during ontogeny can be differentiated; (4) that critical temperatures may appear in the "normal" temperature range for the species.

HAYES, H. K., University of Minnesota: *Virescent Seedling Linked with Japonica in Group 8.* The linkage relations have been studied of a vigorous, virescent seedling appearing originally in an inbred line of Minn. No. 13 dent corn. This virescent proved to be genetically different in crosses from each of ten virescents of known linkage groups designated as v_1, v_2, v_3, v_4, v_5, v_{12}, v_{15}, v_{17}, v_{18}, and v_{20}. It proved independent of *P* and *br* in group I; ts_1, *lg* and *fl* in group II; ts_4, *cr* and *A* in group III; *su*, *Tu* and gl_3 in group IV; *Ch* and *Pr* in group V; *Y* in group VI; *Bn* and *ra* in group VII; *C*, *wx* and *sh* in group IX and *R* and *g* in group X. Recent data in F_2 repulsion with japonica in group VIII gave the following—*V J* 443 : *V j* 165 : *v J* 173 *v j* 7. Studies are under way to test the three point relationship between virescent, japonica and male sterile$_8$.

HOLLANDER, W. F., University of Wisconsin: *A Three-factor Autosomal Linkage Group in the Pigeon.* No definite autosomal linkage has been previously reported for the pigeon, but two sex-linked loci have been roughly mapped. In the present study the plumage coloration of the wild blue Rock Pigeon is considered standard. Three loci, marked by *C* (and C^T, an allele), *O*, and *S*, respectively, show definite linkage, and the order indicated by two-point tests is probably that given. Three-point tests have only been begun. The values obtained in coupling and repulsion phases, and also when heterozygotes are of different sex, are fairly consistent. The greatest difficulty in the tests is the epistasis of *S* over *C* and C^T, and their + allele.

HOLMES, F. O., Rockefeller Institute for Medical Research: *Necrotic Response to Tobacco-mosaic Infection in Paniculata-like Segregates from Nicotiana paniculata × rustica. Nicotiana paniculata* responds to inoculation with tobacco-mosaic virus by mottling, without necrosis. *N. rustica* responds to inoculation with the same virus by systemic necrosis. The necrotic response has been secured in self-fertile *paniculata*-like segregates from the hybrid *N. paniculata × rustica,* obtained by repeated back-crosses using *N. paniculata pollen.* So far as known, this response, characterized by systemic necrosis, is found in but one other species of Nicotiana, *N. undulata.*

HOOVER, MARGARET E., Carnegie Institution of Washington: *An Analysis of the Cut Region of the X-chromosome of Drosophila melanogaster.* An intensive study is being carried out on 18 lethal changes (probably deficiencies) involving the cut locus (20.0) in *D. melanogaster.* Some of these are connected with chromosomal abnormalities (inversions and translocations). A summary of the data accumulated so far is presented relating to: (1) Genetic tests determining: (a) Region, nature and extent of a chromosomal abnormality if crossover data indicate such a rearrangement. (b) Genetic length of a deficiency if a lethal is shown to be involved. (2) Eggs-larvae-pupae counts determining approximately the stage in ontogeny at which the lethal takes effect. (3) "Cell-lethal" tests determining whether the deficiency is lethal to a small group of hypodermal cells. (4) Cytological analysis of salivary chromosomes.

JEFFREY, EDWARD C., Harvard University: *On the Occurrence of Gigantic Sperms in Certain Orthoptera.* Gigantic non-nucle-

ated sperms have long been known in the Lepidoptera among insects and in air-breathing Gastropods. The author has found this phenomenon abundantly present in Orthoptera, particularly in certain crickets and locusts. As in the other groups, the sperms are of gigantic size and are non-nucleate when mature and often multiciliate. An investigation of these as well as the Orthoptera makes it clear that the same cytological abnormalities are present. The cytological resemblance to known hybrids in plants is striking and is further increased by the appearance of sperms which correspond to the dyads and monads of plant hybrids. It is inferred that apyrenospermy and gigantic sperms indicate previous hybridization.

JEFFREY, EDWARD C., Harvard University: *The Cytological Features of Gigantism in Isoetes.* Examples of the genus under the three headings of the *lacustris* type, the *saccharata* type and *the echinospora* type have been studied. A gigantic form of *I. lacustris* has been investigated cytologically. In this case there is almost complete sterility among the microspores, and the megaspores show great diversity of size, some of them representing monads and the others dyads. In the latter the two spores are frequently united so as to resemble a dumb-bell. The reduction division is interesting because it is entirely that characteristic of hybrids. It is inferred that the gigantic *Isoetes lacustris* is of hybrid origin and a similar conclusion probably holds for other gigantic forms in the genus.

JONES, DONALD F., Connecticut Agricultural Experiment Station: *Atypical Growths in Maize Occurring as Mosaics.* Overgrowths in plant and endosperm tissue occur sporadically at different stages of development and in the same order of frequency as mosaics resulting from the loss of dominant genes by chromosomal aberrations of some kind, apparently deficiencies and somatic crossing-over.

KAUFMANN, BERWIND P., University of Alabama: *Cytological Evidence of Pre-reduction in Drosophila melanogaster.* A cytological study was made to determine the type of separation of chromatids which occurs at first meiosis in *D. melanogaster.* For this purpose $\widehat{XX}Y$ flies were used which carry a heterozygous translocation for the second and third chromosomes, with

the translocation point in each chromosome close to the spindle fiber attachment region. Eggs were secured as laid, and either sectioned or prepared as whole mounts following treatment with Feulgen. Several division figures were obtained. In each case the chromosome configuration indicated that segregation occurs at first meiosis. These findings are in harmony with the genetic evidence that separation in first meiosis is disjunctional for the spindle fiber attachment regions of the chromosomes of Drosophila.

LYNCH, CLARA J., Rockefeller Institute for Medical Research: *Mouse Strains and Susceptibility to Tumors Induced by 1: 2: 5: 6-dibenzanthracene.* Two inbred strains of mice were tested for susceptibility to induced tumors. Each animal received a total dose of 4 mg of 1:2:5:6-dibenzanthracene in 1 cc of lard given in 3 subcutaneous injections at 2-week intervals. Thirty-two mice from a substrain of Bagg albinos which has a fairly high rate (37.0 per cent.) of spontaneous lung tumors showed, after treatment, 81.3 per cent. of primary tumors in the lung. The difference is mathematically significant. Thirty-eight mice from Strain 5 which has a low spontaneous lung tumor rate (4.5 per cent.) gave, after treatment, 5.7 per cent. lung tumors—not a marked increase. No spontaneous sarcoma has been observed in Strain 5 and only 1.5 per cent. in the Bagg strain. After treatment the Bagg albinos gave 78.1 per cent. and Strain 5 gave 76.3 per cent. of subcutaneous sarcomas at the site of injection. It is evident that 1:2:5:6-dibenzanthracene can induce primary tumors in the lungs of mice in addition to subcutaneous sarcomas. A significant difference between strains was demonstrated for susceptibility to induced lung tumor but not to induced sarcoma. There was no correlation between the susceptibilities to the two kinds of growth.

MARGOLIS, OTTO S., New York University: *The Facet Relations in Dorsal and Ventral Lobes of Bar-eyed Drosophila.* An investigation of facet number in a closely inbred population of Bar-eyed *Drosophila melanogaster* discloses the fact that the ratio of facet number in the dorsal lobe to facet number in the ventral is constant over the range of temperatures, 22° to 31° C. The value of the ratio for the males varies slightly about 1.15, and for the females about 1.0. At temperatures below 22°, no

accurate discrimination of lobes was feasible. Analysis of data on several hundred flies raised at 28° under carefully controlled experimental conditions showed no significant correlation between the facet numbers in the two lobes of the eye. Under crowded conditions, however, a significant correlation is obtained, the magnitude of the correlation coefficient varying with the degree of crowding. These experiments were repeated on a second unrelated but closely inbred race of Bar flies raised at 28°, and consistent results obtained, showing that the two lobes vary independently of each other. If these results represent generally the relations between dorsal and ventral lobes in Bar-eyed flies, one may utilize the correlation coefficient as a measure of the uniformity of both genetic and environmental factors affecting eye size in a given experiment.

MARSHAK, ALFRED, Woodhaven, N. Y.: *Chromosome Structure in Meiosis and Microsporocyte Division of Gasteria.* Synaptene pairing appears as an intercoiling of homologues, each of which appears at places to be double. This double appearance of the homologue is lost after synapsis and is not evident again, microscopically, until diplotene. Nodes and regions of apparent interchange between chromatids in diakinesis and metaphase are shown to be the result of twisting of individual or pairs of chromatids about each other. True chiasmata appear as interchanges between chromonemata alone. Failure to make this distinction has made literature on chiasmata very confusing. Alignment on the metaphase plate and disjunction of chromatids in anaphase appears to be independent of the plane along which chromatids open out prior to anaphase. This explains the apparent dilemma of Wenrich in having a spindle fiber attachment at either end of a heteromorphic pair of chromosomes in *Phrynotettix.* The attachment and attenuation of pairs of chromatids is correlated with disjunction of chromatids across a chromonematic chiasma. Such chiasmata involve interchanges between the half-chromonemata, the chromonema of each chromatid being visibly two-parted. Of 501 chromosomes, 5 had at least two chromonematic chiasmata; *i.e.,* about 0.5 per cent. of the pairs of chromatids had to disjoin across a chiasma. Anaphases in the same slides showed 4 pairs of attenuated chromatids in 232 observed pairs, *i.e.,* about 1.7 per cent. Of 6,723 pairs of chromatids in other strains of *Gasteria,* 34 pairs were attenuated, making a total of

0.55 per cent. attenuated pairs. Each half chromosome of the microspore prophase is clearly quadripartite. This suggests the possibility of a quadripartite condition of each homologue at synapsis, unless an anaphase without a previous chromonematic division intervenes. X-ray data show that the "reduction" does not occur in the premeiotic mitosis. It is suggested that this may occur at the first embryonal mitosis, which has not, however, been tested yet.

METZ, C. W., and ELIZABETH GAY LAWRENCE, Carnegie Institution of Washington: *Comparative Study of Salivary Gland Chromosomes in Diptera.* Demonstration will include microscope slides and photographs illustrating results of comparative study of salivary chromosomes, mainly in *Sciara,* with particular reference to effects of different fixatives on the internal structure. It is also planned to demonstrate living chromosomes, following the method of Doyle and to illustrate shrinkage effects of aging and of fixation. Other features to be illustrated include the following: Disk-like nature of chromatic cross bands and variability in number of granules in these "bands" (when granules are present). Absence of visible longitudinal striations in relaxed chromosome. Appearance of striations in stretched chromosome. Appearance of striations in stretched chromosome, interpreted as artifacts due to distortion. Differences in type of coagulation in achromatic materials at different levels along chromosome, indicating chemical differentiation and possible genic nature of these achromatic materials.

NABOURS, ROBERT K., and FLORENCE M. STEBBINS, Kansas State Agricultural Experiment Station: *A Translocation to the Sex-Chromosome in Apotettix eurycephalus Hancock (Grouse Locusts).* A portion of one of the first pair of autosomal chromosomes carrying the gene for the dominant color pattern *W* (a tan stripe along the femora of the jumping legs) was translocated and attached to a X-chromosome, probably due to the 5,500 r. u. of x-raying to which the male was exposed. Thus we have, for the first time in the grouse locusts, a sex-linked character. This *W* is also still inherited in the original autosomal or typical Mendelian manner. The quadruple quantity of this part of the first pair of autosomes appears to be lethal to the females at some, as yet undetermined, early stage. An indi-

vidual of either sex bearing a triplicate amount is apparently normal. This latest translocated portion, carrying *W*, at least partially compensates for the absence of the section previously translocated (*OTG*) from the first to the fourth pair of autosomes (*Proc. Nat. Acad. Sci.*, 19: 234–239, 1933), as individuals bearing this deficiency and the now sex-linked portion frequently grow up, the females oftener than the males.

OLIVER, C. P., University of Minnesota: *The Relation of Induced Infertility to the Genetic Effects Induced in Drosophila Males.* Based upon counts of five to twelve thousand female offspring for each of five graded dosages, 380 to 6,088 r units, males subjected to the lowest intensity produced an average number of offspring about equal to controls and slightly larger than the next dosage step (population saturation). With the next three steps, the average number of offspring decreased in proportion to intensity increase; but with the highest intensity, the average number was only one half that expected if proportion held. The three upper dosages were studied for mutants. The total mutation-rate of four genetic effects, visible mutants and sex-linked non-visibles (lethal, translocation, inversion), increased in proportion to intensity used. This proportion held for each of the four effects. For any given intensity, each non-visible effect was induced at approximately the same rate, and each with a frequency about ten times the visible mutation rate. High intensity decreases the male's fertility out of proportion to intensity used. This high state of infertility is not accompanied by as high an increase in mutation-rate for either of the four effects studied. X-rays seem to cause mutations rather than merely to act as a selective agent. Visible mutants occur in controls with half the frequency of sex-linked lethals; following irradiation, the ratio of visible to either non-visible effect is about one to ten. That difference is unexpected if all induced visible and non-visible mutants have a similar basic explanation.

OWEN, F. V., U. S. Bureau of Plant Industry: *Self-fertility and Self-sterility in Beets.* Several degrees of self-sterility and self-fertility have been found in beets. Completely self-sterile, intermediate and fully self-fertile plants have been studied. The results of the work on self-fertility are easily explained on the basis of the factor S_f similar to that described by East for *Nicotiana*. Self- and cross-sterility in beets, however, appear to

be more complicated. The theory of an allelic series of sterility factors does not appear sufficient to explain the results, which are nevertheless clear-cut and evidently governed by some definite rules of inheritance. Some modification of the oppositional theory might be suggested. Pseudo-fertility has been an important factor in the interpretation of results. In beets pseudo-fertility seems to be most pronounced after the plants have been forced to flower several times. Various heritable degrees of pseudo-fertility have also been noted.

PAINTER, T. S. (cytology), and J. T. PATTERSON (genetics), University of Texas: *Localization of Gene Loci in the Third Chromosome of Drosophila melanogaster.* The primary purpose of this study was to locate as accurately as possible, by the salivary gland chromosome method, the position of the gene loci for roughoid, hairy, thread, scarlet, peach, curled, stripe, sooty and claret along the two arms of chromosome III. Normal males were x-rayed (3975 *r* units) and mated to *"rucuca"* or other homozygous females carrying recessive genes. Any deletion or mutation (either simple or accompanying a break) failing opposite a marked locus will show in the F_1 flies. 195 variant flies were found in the 51,829 F_1 individuals examined. Roughoid showed most frequently, followed in order by claret and sooty. In only four instances did hairy show. Of the 195 variant flies, 76 proved sterile, 26 did not breed true, 10 were mosaics, 61 were viable in homozygous condition and hence probably represent simple mutations, and 22 were lethal when homozygous. The latter were studied cytologically and 13 showed chromosome rearrangements, among which were 7 deletions, 3 translocations and 3 inversions. In nine of the homozygous lethal stocks we were unable to detect any evidence of choromosome rearrangements; either the latter were too small to detect or else there are cases of simultaneously produced point mutation lethals. Most of the gene loci concerned were located within narrow morphological limits. In most instances the mutated gene lies at or very close to a point of breakage. A revised cytological map of Chromosome III will be shown.

PATTERSON, J. T., WILSON STONE and SARAH BEDICHEK, University of Texas: *Further Studies on X-chromosome Balance.* The authors are studying inter- and intra-genic balance by

means of a consecutive series of small duplications and deficiencies of the X-chromosome. The influence of this aneuploidy on viability, fertility and phenotype is compared in the hyperdiploid male, hyperdiploid female and hypodiploid female. Different regions are shown to have distinct and independent effects on the variables measured, so that the effect of longer segments is an algebraic sum of its integral parts. There seems to be no consistent relation between the influence of hyperploidy in the two sexes. If a primary sex factor exists, it has been restricted to a relatively small region between the genes furrowed and scalloped.

PLOUGH, H. H., and GEORGE CHILD, Amherst College: *Developmental Modifications in Unhatched Pupae Induced in Genetically Different Stocks of Drosophila by High Temperature.* When *Drosophila* larvae are exposed to a temperature of 36.5° C. for 18 hours, a small number hatch and a large number die in various stages. Those which hatch show many non-genetic modifications, which often parallel known mutations. It has been observed that these modifications differ when genetically different stocks are used. Among the individuals which die are many pupae which appear normal but yet fail to emerge. Freeing these pupae from the pupa cases reveals that all are abnormal and that they show the characteristic anomalies shown by their genetically similar but emerged sibs in more extreme form. These unhatched pupae thus serve as excellent indices for the specific effect of high temperature on genetically different stocks. Demonstrations of the unhatched pupae from three isogenic stocks subjected to the same temperature will be shown.

POTTER, J. S., E. C. MACDOWELL and M. J. TAYLOR, Carnegie Institution of Washington: *Interaction of Host and Normal Tissue Transplants as Indicated by Response to Leukemic Cells.* It has been demonstrated that mice of strain C58, which normally die 4 ± days after inoculation with leukemic cells of line I, are enabled to resist these cells when pre-treated with embryo tissues of strain StoLi or of the F_1 between StoLi and C58. Embryo tissues of strain C58 in mice of strain C58 do not cause resistance, while Balb embryo tissues induce resistance in part of the C58 mice treated. However, when embryo tissues of strain StoLi are implanted in mice of strain Balb the normal

susceptibility of these mice to line R leukemia may be increased. About half of the mice receiving embryo implants die before any of the controls. It therefore appears that interaction of embryo tissues with host tissues may, depending on their genetic constitutions, result in (1) no change, (2) increased resistance or (3) increased susceptibility. C58 embryo skin in C58 hosts grows to form follicles and hair but no resistance results, while StoLi/C58 embryo skin also develops follicles and hair and the host is resistant. Balb embryo skin in C58 hosts is necrotic at 12 days with no indication of any development after implantation, but this combination produces resistance in part of the hosts. StoLi embryo skin in C58 hosts results in resistance, but four days after implantation only scattered mitoses are found while degeneration is general: no follicle formation has been observed. The interaction between host and embryo tissue implant, therefore, does not depend on survival or non-survival of the implant.

ROBERTSON, W. R. B., State University of Iowa: *Morphology and Cytology of a Gynandromorph of Paratettix texanus.* Produced bisexually by R. K. Nabours, its genetic formula is *E/K Spk/spk sf/sf.* The specimen was labeled male on left and female on right. It is found, however, that this applies chiefly to the external anatomy and then to only the posterior four or five abdominal segments. Internally there is a testis and accessory male sex glands. Although produced bisexually the individual shows spermatogonial divisions with chromosomes grouped as in partheno-produced cells. Some of the tetrads in primary spermatocyte divisions tend to stick together, while secondary spermatocyte metaphases are of two types, with three diads clinging together and four free or with two diads associated and four free.

ROBERTSON, W. R. B., State University of Iowa: *The Chromosomes of Nabours and Stebbins's Sex-linked Translocation in Apotettix eurycephalus.* The genetic data indicate a translocation of the right end of the autosomal linkage group containing the gene for *"W,"* stripe on the sides of the femora, to the X-chromosome. The cytological findings confirm this and also indicate that the translocation is also reciprocal, between one of the intermediate sized autosomes and sex-chromosome. The

latter is abnormally long and shows a sub-median constriction. One end of an unequal tetrad seems to be correspondingly shortened and likewise shows a point of differentiation along its axis. In connection with the first found translocation (*OTG*) of this end of the linkage group of *Apotettix* it may now be possible to identify with greater certainty the cytological chromosome concerned.

SATINA, SOPHIE, and A. F. BLAKESLEE, Carnegie Institution of Washington: *The Assortment of Chromosomes During Megasporogenesis in Triploid Daturas.* Triploid Daturas when selfed or used as the female in crosses to diploids produce a deficiency of extra chromosomal types and an excess of 2n offspring over the number expected from random assortment from trivalents observed in pollen mother cells. The present study was undertaken to discover what, if any, peculiarities in development of the female gametophyte might be responsible for this excess of 2n offspring. Chromosomes were counted during meiotic division of the megaspore mother cells. Distribution of chromosomes in the first division occurred at random giving the expected binomial curve of distribution for the 100 m. m. c. studied. Particular attention was paid to the daughter nucleus at the chalazal end from which the embryo sac in *Datura develops.* Development of the sister micropylar nucleus was never found, even in those cases in which the chalazal nucleus aborted. Of the 100 m. m. c., 57 showed one or more detached chromosomes. Lagging chromosomes were also frequent in the second division. The elimination of such lagging chromosomes is responsible in part at least for the preponderance of megaspores with 1n chromosomes, where otherwise larger numbers of chromosomes would be expected. A considerable reduction in chromosome number therefore occurs before the formation of the egg cell. It can be concluded that excess of 2n types in the offspring of triploids results from the peculiar behavior of chromosomes in the female gametophyte. The investigation further shows it is unsafe to assume that the behavior of chromosomes in male and female gametophytes is necessarily alike.

SAWIN, PAUL B., Brown University, and Bussey Institution: *Inheritance of Homeosis in the Axial Skeleton of the Rabbit.* In the rabbit, variation in the number of ribs and of presacral

vertebrae (indicators of homeotic variation in the thoraco-lumbar and lumbo-sacral regions) is continuous. A previously reported arbitrary classification into four type formulae is inadequate for a genetic interpretation, since none of these types breed true without prolonged selection. Study of several generations in each of three families shows that, whereas in one family there appears to be a normal Mendelian segregation of the extra ribbed and normal types in hybrid and backcross matings, no corresponding behavior is to be observed in the inheritance of the number of presacral vertebrae; nor is segregation of either variation clearly defined in the other two families. Comparison of the percentage of individuals having extra ribs; the percentage having an extra presacral vertebra and the degree of expression of the extra ribs when present in these families indicates homeotic variation to be centered in a different region in each of these families. In the first family the thoraco-lumbar region is primarily involved. In the second a close correlation exists between variation in the two regions and in the third family variation in the lumbo-sacral region exceeds that of the thoraco-lumbar and frequently is unaccompanied by it, in which case it does not breed true. Although critical data are not available, it is not improbable that the variation has its causation in underlying developmental agencies of a multifactorial nature similar to those which produce increased body size.

Scott, J. P., Wabash College: *Development of the Polydactylous Monster of the Guinea Pig:* This monster, as previously shown by Wright, is the product of the homozygous condition of a semi-dominant unit factor, *Px,* which in the heterozygote produces the atavistic return of one to all of the normally absent digits and increases the average birth weight 7 per cent. Monstrous embryos of two inbred stocks were compared with their most advanced litter mates. Recognizable defects appear at 18½ days of gestation (33 somites) as lateral folding of the neural tube in the region of cervical flexure and as microphthalmia. The gene appears to act through inhibition of morphogenesis and stimulation of growth rate. The defects of embryonic posture, club feet (in part), muscular anomalies, short sternum, hare lip, reduction of the viscera, and deformities of brain and kidney are accounted for as the result of freezing of embryonic form by the relatively early onset of histogenesis. Alteration

of size relationships accounts for cleft palate, overgrowth of certain parts of the brain, and secondarily for hydrocephaly, polydactyly and microphthalmia. Miscellaneous defects are: failure of the tibia, inhibition of extra nipples, disturbance of vibrissa pattern and production of excrescences. Most monsters die about 26 days from subcutaneous hemorrhage in the dorsal neck region. Heterozygotes are not identifiable until digit formation; only feet and sternum are affected. The action of the gene appears to be general, no functional vital organs being affected at first. The monster is unique in type and in that it does not show a general inhibition of growth.

SHULL, GEORGE H., Princeton University: *Oenothera seg. petiolaris, a New Biotype Manifested through the Disappearance of a Lethal Factor. Oenothera* mut. *erythrina* is a well-known "half mutant" of *Oe. Lamarckiana,* which has always segregated when selfed, giving *erythrina* and seg. *decipiens* biotypes in a ratio usually approaching the theoretically expected 2:1. The *decipiens* biotype is a homozygous form with seven pairs of chromosomes. It may be considered a modified *gaudens · gaudens* type rendered able to manifest itself in pure-breeding form by the loss of the zygote lethal which is normally included in the *gaudens* complex. Among several specimens of *erythrina* which were selfed in 1934 one has given in 1935 a progeny consisting of the expected 2:1 ratio of *erythrina* and *decipiens,* plus a third type, which has been named seg. *petiolaris* because of the strikingly long petioles and short blades of the rosette leaves. It is reasonable to assume that this new type is a modified *velans · velans* which has appeared in homozygous form through the disappearance of the zygote lethal which normally lies in the *velans* complex. Seg. *petiolaris* is notable for unusual bud and flower characters as well as leaf form. The sepals separate except at their tips in very young stage and remain in this shape throughout development. Sepals and petals are both unique in form.

SINNOTT, EDMUND W., Columbia University: *The Histological Basis of Size Differences in Some Cucurbit Fruits.* The size of ovaries and fruits, and of their constituent pericarp cells, were measured from the earliest visible stages to maturity in various members of the *Cucurbitaceae* differing greatly in fruit size.

These differences are not merely in amount of growth along an identical developmental path. The same fruit size may be attained by a great expansion of a relatively small number of cells (watermelon) or a much less expansion of a greater number (mammoth pumpkin). Cell division ceases at about the time of flowering, and cell expansion is stopped by the formation of the secondary cell wall. At least four processes are thus involved in fruit size differences—cell division, cell expansion, attainment of sexual maturity and development of secondary cell wall. The rate of each process seems to have an independent genetic basis.

SINNOTT, EDMUND W., Columbia University: *A Simple Case of the Effect of Size Difference on the Expression of a Shape Genotype.*—The fruits of two varieties of the "bottle gourd" (a race of *Lagenaria vulgaris*) differing greatly in size were measured during all stages from flower-bud to maturity. When length is plotted against width (both logarithmically) all points for both varieties fall along the same straight line, but with length growing only about 0.8 as fast as width during development. Increase in size thus produces marked changes in the ratio of length to width. The small race is essentially like an early developmental stage of the larger one. Both seem to have the same genetic constitution as to shape, but the expression of this is marked affected by the size attained. The latter evidently has a distinct genetic basis.

SMITH, H. H., U. S. Bureau of Plant Industry: *The Relation Between Factors Affecting Color and Size in Certain Species of Nicotiana.* Populations resulting from crosses between *Nicotiana Langsdorffii* and *N. Sanderae* were analyzed for genetic factors which control color and size of corolla. Seven genes with major effects on anthocyanin color, one factor for chloroplastic color and two complementary genes causing blue pollen were studied. *Langsdorffii* has a small corolla; *Sanderae* (Sutton's Scarlet) a large one. Both parents were reasonably homozygous. Their corolla size was of comparable variability and the F_2 frequency curve was approximately normal when the data were compared on a logarithmic scale. All the results were compatible with the general statistical requirements of the multiple factor hypothesis. Some observations were made on rela-

tive growth rates during stages in the development of the corolla. Each of the genes from Sutton's Scarlet was found to be associated, on the average, with larger sized corollas in the F_2 generation. This and further evidence was interpreted as indicating linkages between qualitative and quantitative characters. The relationship was usually less pronounced, but nevertheless evident, in subsequent generations. Cumulative series were constructed by adding a single color factor at a time from the larger parent. There was a progressive increase in corolla size. Apparently a large number of size factors are involved; some, if not all, are non-dominant; and none have detectable major effects. Many of the quantitative genes appear to be additive, while others interact. Consistent results indicating interactions of the type predicted by Rasmusson (1933) were found. This work was carried out at the Bussey Institution of Harvard University.

SMITH, LUTHER, University of Missouri: *Cytogenetic Studies of Triticum monococcum and T. aegilopoides. T. monococcum* vars. *flavescens, vulgare, pseudovulgare* and *Hornemanni* (n = 7) × *T. aegilopoides* var. *baidaricum* (n = 7) have a ring of 4 plus 5 closed bivalents at MI in PMC of F_1. At diakinesis and MI the ring has the appearance of a typical segmental interchange. F_2 gave 192 normal : 192 ring : 16 asynaptic plants. Although the chromosomes in the ring open out alternately only in approximately one half the PMC, many ring plants produce normal pollen and over 50 per cent. fertile ovules, suggesting directed segregation. The asynaptic plants are characterized by complete failure of pairing at diakinesis and MI. They are vegetatively vigorous but produce no good pollen and very rarely a functional ovule. The inheritance of asynaptic from limited data in F_3 fits an hypothesis of two unlinked factors independent of the chromosomes forming the ring. *T. monococcum flavescens* × *T. aegilopoides stramineonigrum* has 7 pairs in F_1. Thus the chromosomal difference responsible for the ring is not characteristic of the species. Intra-specific hybrids in *T. monococcum* (*flavescens* × *vulgare, pseudovulgare,* or *Hornemanni*) have 7 pairs in F_1. The intra-specific hybrid, *T. aegilopoides baidaricum* × *stramineonigrum,* has a ring in F_1 and half the F_2. No asynaptic occurred in an F_2 of 108 plants. Thus these varieties differ in the ring-forming complex but are identical in the asynaptic complex. Numerous mutants have been induced in *T.*

monococcum by x-ray treatment. Linkage determinations are in progress for 12 selected mutants. Two mutant recessives for early maturity make possible 3 to 4 generations per year.

SMITH, T. L., College of the Ozarks: *Synopsis of Work on the Biology, Culturing Methods and Genetics of Galleria mellonella, Linn.* *Galleria mellonella* is an exceedingly viable and hardy organism and is readily adapted to laboratory handling. Since it is also a highly fecund form it was chosen for some genetic experimentation. Its culturing was adapted to the general breeding apparatus used in Drosophila work, with some modification. The breeding cycle requires about eight or nine weeks. Females lay 200 to 1,000 eggs or more. Eggs hatch in about 10 days. The larval stage lasts four to five weeks, during which time there are eight instars with their terminating ecdyses. The adults live a week to ten days but never eat. The chromosomes are very small short rods. The diploid number is 60. The genetic work began with a wild stock of this species. These were inbred for three or more generations. No natural mutants showed up. The moths were treated with x-rays and radium emanations. Effective dosages range from 4,500 to 5,000 roentgen units. About thirty-five or more mutations have arisen from the irradiation treatments. These are all recessive to the wild condition. Only one definite case of linkage has been discovered to date. This case involves light body color and rolled scales. The cross-over percentage between these two genes is 2.21. Facultative parthenogenesis occurs in about 10 per cent. of isolated virgin females. Non-fertilized eggs require several weeks to hatch. The impaternate offspring from a given female are few in number—one to ten in most cases—and are of both sexes and apparently normal in every respect. These are interpreted to arise by chance from eggs in which the second polar body is reclaimed as a fusion nucleus with the egg nucleus. This would restore the diploid number of chromosomes which the impaternate individuals apparently have. There are occasional gynandromorphs. These are generally bilateral. Besides these sex mosaics there infrequently arise peculiar mutant-normal mosaics, *i.e.*, moths which show the mutant character in one half of the body while the other half is normal. These arise from heterozygous parents, some of which are back crossed. Most of these mosaics have also been bilateral. Their frequency is

approximately the same as impaternate offspring. The interpretation given is that these latter arise from double fertilization of binucleate eggs. Thus a binucleate egg if unfertilized develops parthenogenetically; if it is marked with recessive genes and is appropriately double fertilized, it produces the gynandromorph or the mutant-normal mosaic.

SMITH, WILLIAM K., University of Wisconsin: *Biochemical Studies Relating to the Waxy Gene in Maize.* To characterize more precisely the differences found by Brink between the action of the waxy gene in maize and the normal allele, waxy starch and common maize starch were hydrolyzed by the enzymes alpha-amylase and beta-amylase. The rate of hydrolysis for the two starches was the same under the action of alpha-amylase (takadiastase). With beta-amylase (barley), waxy starch showed a higher initial rate of conversion to maltose than non-waxy. Since the precise nature of the action of alpha- and beta-amylase on starch is as yet obscure, the significance of this observed difference for the determination of the chemical structure of the waxy and non-waxy starch molecule is not clear. Attention was then turned to the amylases associated with the waxy and non-waxy gene in the pollen. Extracts made from the autolyzed pollen of waxy and common maize plants differed in their action on a given starch. Does the amylase system associated with the waxy gene differ in quantity or in kind from that associated with the non-waxy? By modifications in the methods of enzyme purification of Willstätter and Waldschmidt-Leitz, it has been shown that in waxy as well as in non-waxy pollen both alpha-amylase and beta-amylase are present. In the comparative assay of alpha-amylase the waxy and non-waxy did not respond in the same way to a given change in the method of extraction, thereby suggesting a difference between the two alpha-amylases. A qualitative determination should therefore precede a quantitative one. A beginning has been made on qualitative tests.

SPENCER, W. P., College of Wooster: *A Teaching Model of Crossing-over in the X-chromosome of Drosophila hydei.* By the use of a large cardboard model including a rotary disk, color and lighting effects, the several cytological cross-over combinations involving the genes for vermilion eyes, scute bristles, miniature wings and cherry eyes are presented. Simultaneously with

the appearance of each contrasting pair of cross-over chromosomes the corresponding combinations of phenotypic characters are shown. The model includes a graphic demonstration of the mechanism of reduction in crossing-over through the effect of a duplication of a part of the X-chromosome, with data on normal and reduced cross-over values.

STADLER, L. J., and G. F. SPRAGUE, University of Missouri: *Genetic Effects of Ultra-Violet Radiation in Maize.* Ultra-violet radiation applied to mature pollen induced deficiencies, translocations and point mutations. The radiation used was that from a quartz mercury-vapor arc, and the genetic effects were determined as in previous experiments with x-rays. The frequency of deficiencies marked by endosperm genes was roughly proportional to dosage. The maximum frequency was equal to that from fairly heavy x-ray treatments. Radiation filtered through 1 cm 1/55 $HgCl_2$ solution (which absorbs all wave-lengths shorter than 280 μμ and materially reduces the intensity of wave-lengths shorter than 289 μμ) produced a distinct increase in the frequency of deficiencies marked by endosperm genes. Radiation through 1/3.5 $HgCl_2$ (which absorbs all wave-lengths shorter than 297 μμ and materially reduces intensity of wave-lengths shorter than 302 μμ) had no effect on this frequency. Thus wave-lengths longer than about 300 μμ are ineffective.

STEELE, DEWEY G., and MILLER, IVAN R., Connecticut State College: *A Quantitative Study of the Pigments in the Basic Color Types of the Domestic Pigeon.* Quantitative determinations of the melanin in each of the principal color types of the pigeon have been made by means of the Einsele technique. The results show the quantitative effect of the clumping and dilution factors in combination with black, brown and red pigmentation. The technique will be demonstrated and the results presented in tabular form. The color types involved in this study will be exhibited, and microscopic sections will be available to further demonstrate the physical basis of coloration.

SUCHE, META L., University of Texas: *Crossing-over and Disjunction in Translocations.* The relation is shown between crossing-over and disjunction and changes in length and regions involved in 3–4 translocations of *Drosophila melanogaster.* In

heterozygous tests crossing-over is reduced near the break when in the euchromatic area. In an exceptional case involving attachment in the chromocenter crossing-over is increased near the spindle and decreased in distal regions. In homozygous translocations with the break in or near the chromocenter crossing-over in all regions is normal or slightly increased. In other cases homozygous crossing-over is decreased in the translocated fragment and increased in other regions. In all heterozygous males disjunction is alike, regardless of the locus of the break. The production of approximately 50 per cent. disjunctional gametes suggests that segregation is at random for one, probably the translocated, fragment and normal for the other. In females heterozygous for a translocation the effect of crossing-over and related phenomena is seen in the decrease in non-disjunction as cross-over values approach the normal. Non-disjunction is inversely proportional to the length of the translocated fragment and directly proportional to cross-over decrease. This relation is further shown by the addition of an inversion. In males disjunction is but slightly decreased, whereas in females the 50 per cent. decrease must be correlated with cross-over decrease. In homozygous translocations disjunction is approximately normal in both sexes and independent of the length of the translocated fragment.

WEETMAN, LESLIE M., Marquette University: *Inheritance and Correlation of Shape, Size and Color in the Watermelon.* Data from four distinct crosses in the watermelon indicate conclusively that elongate and spherical fruits differ by a single genetic factor, with no dominance of either shape. Ovaries of the unopened flower buds were highly correlated with the mature fruits in shape but fell into more sharply delimited classes than did the fruits. There was highly significant correlation of shape of fruit with weight of fruits ($r = 0.34$ and 0.41 in F_2), the association being such that the longer fruits tended to be the larger. An extremely small seed type seemed to be due largely to a single dominant gene. Light background color of the rind, the peculiar mottling (IB) of the Iowa Belle watermelon and a fine line stripe were each due to single recessive genes though other factors caused certain variations in some crosses. Broad striping was recessive when crossed with dark-colored melons, but dominant when crossed with light-colored melons. The hypothesis

is advanced that dark rind color, striping and light rind color form a multiple-allelomorphic series, with dominance in the order named. The IB gene was linked with these allelomorphs. The Iowa Belle rind marking was correlated with weight, length and width of fruits, but was not linked with shape. Thus, there seems to be evidence of a second gene for size independent of the one associated with shape.

WEINSTEIN, ALEXANDER, Johns Hopkins University: *The Variation of Coincidence with Distance.* In calculating coincidence it is necessary to distinguish between inclusive, select and partial types; and between various kinds of partial coincidence. In *Drosophila virilis,* all types of coincidence increase from 0 to about 1 with lengthening of the intermediate region; select coincidence then declines, while other types remain at 1. This shows that intermediate regions of about 40 or 50 units are more frequent than those of lesser or greater length; and that regions separated by distances at least as long as the modal one are independent. The results are based on over 80,000 individuals and are all consistent and statistically significant. In *Drosophila melanogaster* some results agree with those in *D. virilis;* in others all types of coincidence decline after attaining a maximum; in still others there is no decline in any type. If the two species really differ in coincidence, the difference may be due to the fact that in *D. melanogaster* the distances are genetically shorter and closer to the spindle fiber. The decline of select coincidence is not, as has been suggested, accounted for by undetected crossing-over in the intermediate region; for this would raise instead of lower the apparent value of select coincidence; a fact which follows from the formula and is borne out by calculations. The existence of a modal distance between adjacent crossing-over also follows from the formula when the genetic length of the chromosome is sufficiently great, even if the regions involved are independent of each other.

WELLHAUSEN, E. J., Iowa State College: *Selection for Virulence in Bacterium stewartii (Smith) Migula by Repeated Passage through Resistant and Susceptible Inbred Lines of Maize.* Two strains of *B. stewartii,* one virulent and the other comparatively avirulent, were repeatedly passed through resistant and susceptible hosts. Both strains after nine repeated passages

through a highly resistant inbred line of dent corn were sharply increased in virulence. In contrast, both strains after nine repeated passages through a susceptible inbred line of Golden Bantam sweet corn, under identical conditions, were greatly reduced in virulence. The greatest progress towards an increase or decrease in virulence was made within the first six passages. After reisolation of each train eight colonies were taken, the progenies of which constituted the culture for the next passage. A distinct positive correlation between degree of virulence and vigorousness of growth on nutrient dextrose agar was evident. The resistance or susceptibility of the two host lines used was found to be definitely inherited on a genetic basis. In crosses of these two lines resistance was dominant. Analyses of the later generation progenies, using a virulent strain of the organism, showed definite segregation of factors for resistance with a strong indication that two major dominant complementary genes were involved.

WILLIER, B. H., T. F. GALLAGHER, and F. C. KOCH, Universities of Rochester and Chicago: *The Action of Male and Female Hormones upon the Reproductive Glands and Ducts of the Chick Embryo.* A single injection of 0.1 cc sex-hormone solution (aqueous or ethylene glycol) of varying potency was made into the albumen of eggs of 24 hours' incubation and development continued until the nineteenth day (*cf.* Kozelka and Gallagher, '34). The eggs used came from brown Leghorns and from a sex-linked cross. Over 350 embryos have been examined. Theelin and theelol (56 to 2,250 rat units) do not affect the size, form or histology of the left and right ovaries of genetic females or the right testes of genetic males. The left testis, however, becomes changed in form to a flattened ovary-like structure consisting of both cortical and testicular tissues (ovotestis). In extreme cases (2,250 units) the testicular cords have been replaced largely by medullary cords. The difference in response of the two testes is attributed to the presence of a germinal epithelium (incipient cortex) on the left testis only during early development. In both sexes the Wolffian ducts appear unaffected. The oviducts persist in the males: with larger dosages they became enormously swollen in both sexes. Male hormone from bull testis extracts (10 to 200 bird units) produced no observable effect on the gonads or oviducts of either sex; Wolffian ducts

may be modified. Male urine extracts of similar hormone concentration while ineffective in producing changes in the female gonads apparently caused the formation of cortex on the left male gonad and a flattened form, whether or not female hormone is present. The Wolffian ducts in both sexes are consistently and tremendously swollen. The oviducts of the females seem inhibited, *i.e.*, rudimentary or absent altogether.

YAMPOLSKY, CECIL, *The Cytology of the Ovarial Trichomes of Mercurialis annua—a Morphogenetic Study.* A mature trichome is twenty to forty times the size of the epidermal cell from which it arises. All parts of the cell show a correlative increase in size. The nucleolus becomes several times the size of the unmodified epidermal nucleus. The pro-chromosomes, the permanent bodies of the nucleus often become as large as the nucleus of their origin. The homogeneity of the pro-chromosomal material is retained in the exaggerated ones and there can be no question of division of chromomeres to account for their increased size. Increase in size is due to a distension of constituent parts. Living nuclei show no organization save for the nucleolus. Severe mechanical handling and treatment with acetocarmine crystallize out a nuclear organization otherwise invisible. Therefore fixed and stained material showing nuclear organization arouse the suspicion of artefact. Trichomes may be classified with glandular structures and may be placed in the category of physiological manifestations seen in the salivary glands of dipteran larvae. The organization of the germ cells of *Mercurialis annua* can not be deduced from the enlarged nucleus of the trichome. On the contrary, the new function assumed by the developing trichome seems to impress itself on the whole cell and its form becomes a visible-to-the-eye expression of forces that can not be evaluated in terms of the visible. The nucleus can no longer be regarded as a directing agency but has become a passive organ caught in the current of function. It is buffeted about at will and becomes misshapen and distorted by forces which it may have previously controlled. And for that reason it can not be held responsible for the scars and mutilations it parades.

SHORTER ARTICLES AND DISCUSSION

THE SEX-DETERMINING MECHANISM OF *DROSOPHILA MIRANDA*

DOBZHANSKY[1] has discovered in *Drosophila miranda* a remarkable new system of sex determination which has presumably been derived from the XY system found in all its immediate relatives. Its character is important, therefore, in showing not only a new method but also an evolutionary change of method. Dobzhansky shows clearly that this species has an X–O mechanism like that of Orthoptera and that this mechanism is superimposed on the older XY mechanism. He is led to assume, however, that both are effective in sex determination. There is then an X^2–O segregation combined, and, what is more, correlated, with X^1–Y segregation; X^1 and X^2 although unconnected go to the same pole.

This is a drastic assumption, as Dobzhansky recognizes. It almost uproots genetics. But there is an alternative that seems to fit the published evidence equally well, as follows:

(1) The X^1–Y pair is effectively homozygous with regard to sex. It contains a middle "pairing segment," derived from the type of presumably homozygous pairing segment of X–Y in other species, while its arms are derived partly from autosomes and partly from sex-indifferent parts of X and Y. Differences in size between the paired chromosomes are due to structural changes having no relation to sex.

(2) The X^2 chromosome contains the sex-differential part of the X chromosome of the other species. It has possibly taken its attachment chromomere by interchange from the fourth chromosome.

(3) The essential sex-mechanism is therefore X–O. The pairing segments of X^1–Y still show the special pairing mechanism by reciprocal chiasmata found in X and Y of the other species and a failure of pairing in the salivary glands. The displaced mechanism survives its use. This it should do, in my view,[2] even if the pair are homozygous, since the mechanism is a genotypically controlled property of the pairing segments of these chromosomes. These segments would be expected to survive structural changes

[1] Th. Dobzhansky, *Genetics*, 20: 377–391, 1935.

[2] C. D. Darlington, *Genetics*, 19: 95–118, 1934.

intact longer than any others, since only their complete replacement by autosome segments would give a working autosome mechanism, and these segments of specialized behavior may contain necessary genes. Nevertheless, those arms of "X^1" and "Y" which are not inert should correspond in structure even though they do not pair in the salivary glands of *D. miranda,* and the hypothesis can best be tested in this way.

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THE NATURE OF APTERY IN THE APTERYGOTA

QUITE apart from its intrinsic interest, the question of the primary or secondary nature of the apterous condition of the Apterygota is of considerable importance to theories on the origin and phylogeny of Insecta. It is rather strange, therefore, that whilst this problem has been briefly discussed in many papers, as incidental to their main subject, there seems to be no complete, or even adequate, review of the evidence relating to the wingless condition of the Apterygota. The object of this paper is to fill the gap and, whilst it would be too optimistic to expect widespread acceptance of the views expressed, it may serve to encourage a more critical approach to the subject than has hitherto been accorded.

It is for this reason that, before giving my own opinion, I wish to draw attention to the looseness of the arguments which have been used (and widely accepted) as suitable for the solution of this problem.

Lankester's view (1904) is scarcely worth consideration, because he merely expresses the belief that the Apterygota have secondarily become apterous, only supporting his opinion on the ground that the "wingless" birds (Ratites) have done the same thing. Though this is certainly suggestive, it can hardly rank above an analogy, and even then the cases are not strictly parallel. In the Ratites there is clear morphological evidence of the previous possession of wings, but there are no such traces of wings in the Apterygota.

There are two direct ways of settling the problem, but both prove unsatisfactory at present. The first is the developmental method, which is to see whether the Apterygota show any signs of having had wings in the past. Unfortunately, even if they

do not, their primarily apterous condition is not proved, because other apterous insects, whose secondary aptery is beyond doubt (*e.g.*, Anoplura), similarly show no trace of ancestral wings. This means that such evidence would only be useful if of a positive kind. The only suggestion that Apterygota do show such wing vestiges (so far as I am aware) is that of Sulc (1927) concerning the prothoracic flaps of *Lepisma*. He claimed that their tracheation shows a reduced condition of the typical pterygotan wing venation. A possible—though not very sound—criticism of this is that such structures might only represent an incipient stage in wing formation. Far more damaging are the objections of Tillyard (1930), who says that dissections show that the tracheation of the flaps is variable, not only amongst different members of the species, but even on right and left sides of the same individual. Evidently any suggested homologies are too fanciful to deserve serious consideration.

The second chance of direct solution is offered by paleontology, in the form of the supposed fossil insects from the Lower Devonian. Since Handschin (Tillyard, 1932) and Carpenter (Tillyard, 1928)—both experts on the Collembola—are satisfied as to their affinities, it seems futile to deny that they are Collembola. Raymond (1931) has suggested that their antennae are surprisingly like those of *Lepidocaris* (a Crustacean very plentiful in the Rhynie Chert), and suspects that the two are related. Tillyard (1932), however, has pointed out that the antennae of *Lepidocaris* are biramous, and that their antennules (which Raymond probably means) arise from a different part of the head than do the antennae of *Rhyniella*. What Tillyard (1928) does not seem to realize (for he claims that these fossils prove that apterous insects preceded the Pterygota) is that the presence of a collembolan head capsule does not prove that apterous insects were in existence. Surely those people who believe that Collembola were primarily winged would expect them to have an ancient history, and would regard these fossils as the probable winged ancestors. At least this is a possibility which can not be ignored. In his original paper on the fossil, Tillyard (1928) suggests that these Collembola may have had more segments than their modern representatives; so why should they not also have had wings? Tillyard, indeed, unconsciously hints at this criticism, when he speaks about another fossil insect (*Rhyniognatha*), of which only

the jaws were found. He says that it is not possible to tell how far this insect had gone towards the Pterygotan stage!

Tillyard (1932) now claims that Scourfield has found almost the whole of the exoskeleton of *Rhyniella,* and this may form a solid basis for Tillyard's conclusions, if the thorax is sufficiently well preserved to show that it did not bear wings. He also says that ecological conditions in the Lower Devonian were unsuitable for the evolution of flying insects. But I am sure that he would agree that this fact can only be used as confirmation of direct evidence, and not as an adequate basis for a theory.

Tothill (1916) adopts the extraordinary expedient of treating the Apterygota as a whole. He selects all the primitive, and all the specialized features to be found in the Apterygota, whether found in all three orders or only in one. Balancing this evidence, he decides that the Apterygota show more of the specialized than of the primitive features, and must therefore be derived from the Pterygota and be secondarily wingless. The objection to such a method is that two of the three apterygotan orders might be supplying specialized features which obscure the primitive features from the third. It is surely necessary to deal with each order separately, and on its own merits, if the conclusions drawn are to be of any value. Had Tothill admitted that the Apterygota were bound together by their primitive aptery, this criticism would not have been so serious. But, if the Apterygota are secondarily apterous, it is unlikely that they are a monophyletic group, and the weakness of his argument is apparent.

Suppose, then, that we take one of the apterygotan orders and analyze its features, finding some to be specialized and others to be primitive. Should the latter predominate, it is not fair to argue that, because the Pterygota are therefore presumably derived from the Apterygota, the latter are primarily apterous. This is because we have admitted that the Apterygota are specialized in some respects, so we can not deny the possibility that aptery may belong to this category. If the balance is held to lie in the other direction, and the Apterygota are thought to be derived from the Pterygota, this criticism does not apply. This apparent paradox arises because no one denies that the winged condition is primary within the Pterygota, so that any forms descended from them must necessarily be secondarily apterous.

Consequently, it is necessary to examine very carefully the possibility that Apterygota are more specialized than the Ptery-

gota. Unless this claim can be upheld for every one of the three orders, it can not be used to support the theory that aptery is secondary in all Insecta. As I wish to refute this latter idea without unduly prolonged discussion, I will consider only the Thysanura, which I think can be shown to be fatal to such a theory. One thing that is frequently lost sight of in such discussions is that no value can be given to specializations which may have occurred *within* the order. The search must be for those features which are characteristic of the order, and these are most likely to be found in undegenerate, free-living forms. The "typical" thysanuran, *Machilis* (*Petrobius*), answers this purpose well. The following is a complete analysis of its characteristics, together with relevant comments:

Head: Filiform antennae—unlikely to be considered anything but primitive.
Eyes well-developed and typical, showing no signs of degeneration.
Three ocelli—the generalized number.
Mouthparts exserted, and admittedly the most primitive in Insecta.
Tritocerebral rudiment better developed than in Pterygota.
Head not bent at an angle to the body—the primitive condition.

Thorax: Almost universally held to show the primitive condition.
Legs generalized, and possessing sub-coxae.
Coxal spurs, probably primitive, but of doubtful significance.
Tarsi three-segmented. May possibly be a reduction from a five-segmented state, but such a loss often occurs within a Pterygotan order (*e.g.*, Hemiptera).
Wings absent—may be primitive or specialized!

Abdomen: Possesses full complement of segments.
Caudal filament may be telson fused with last tergite.
Reduced appendages on all segments—a primitive feature unparalleled in the Pterygota.
Genitalia more complete (extra pair in male) and less specialized than in any Pterygota.
Sub-coxal sacs shared with some Myriopoda, so unlikely to be secondary specializations from Pterygotan ancestors.
Cerci many-jointed—perhaps the primitive condition. They also have cercal glands opening on them as in certain Myriopoda.

Integument: Covered with scales, but this is probably a specialization within the order, as in some Pterygota (*e.g.*, Diptera).

Gut: Enteric caeca (six) present, though poorly developed. Proper salivary glands. The whole impression is one of simplicity, but shows no signs of degeneration.

Excretion: Twenty normal Malpighian tubules.

Nervous System: Three free thoracic ganglia, and eight free abdominal ganglia, with well-separated connectives. The most primitive arrangement in the Insecta.

Tracheal System: Nine pairs of spiracles—one pair lost. The same thing happens, more markedly, within Pterygotan orders (*e.g.*, Hymenoptera). The lack of anastemosis of the branches may be primitive or not.

Heart: Extends forward into the thorax, and has nine chambers. Certainly primitive.

Reproductive System: Seven panoistic ovarioles, not quite segmentally arranged. Three-lobed testes, with vasa deferentia showing traces of segmentation. Probably more primitive than any Pterygotan condition.

Metamorphosis: Simple, because not complicated by wing development.

It is useless to point—as Tothill (1916) does—to specializations and degenerations which have occurred in other members of the group—since such insects are as likely to have been modified from Machilid forms as to have come from Pterygotan insects. Of *Machilis* it would be absurd to suggest that the balance lies in any but a primitive direction. I would go further and say that in all features *Machilis* seems to be more primitive than the Pterygota and to be likely to be ancestral to them. Whilst I admit that this can not carry the weight of direct proof, there seems no reason to deny that this analysis shows that *Machilis* is primitive in every way—including its aptery. This, then, affords sufficiently clear proof that apterygotan insects preceded Pterygotan insects—though not necessarily that all Apterygota are primarily apterous. I have shown that Thysanura are, and it is likely that this is also true of the Protura. These are anamorphic (a primitive condition, unknown in the Pterygota), and thus extremely unlikely to have descended from the Pterygota. Thus since Pterygotan ancestors were apterous, the apterous condition of the Protura is probably primary. Such arguments can not be applied to the Collembola, since they have many specializations, but Scourfield's discoveries may prove that they, too, have never had wings.[1]

[1] Since this paper was written Scourfield has kindly sent me tracings of further fossil insects from the Rhynie Chert. As his material is not yet published I do not wish to reveal any details, but it shows that the thorax is most unlikely to have borne wings, and incidentally seems to settle any controversy as to the identity of Rhyniella as a Collembolan. The aptery of these insects is made more probable by the fact that no trace of wings has been found in the Rhynie Chert. It is unlikely that they have been overlooked, or not preserved, since it is rare to find bodies in other deposits, even when wings are abundant.

In conclusion, I would suggest that the development of wings in the Exopterygota has never been given the attention which it deserves, as an argument in favor of the secondary nature of wings in Insecta. In view of the very few morphological changes (apart from the obvious developmental maturation of the gonads) which occur during the life of non-aquatic exopterygote insects, it must surely be a matter for surprise that the wings should be acquired so late. If they are useful in the adult form (and in many cases they are of great importance) there seems little reason to suppose that the earlier instars would not equally be aided by their possession. Why, then, do they appear so late? It is surely not misusing the undoubted testimony of the recapitulation theory to suggest that it is because wings have been acquired more recently than other structures, and that their formation has not yet been pushed back into embryological development, or even to the earliest stages of larval life. It is especially significant that in many Exopterygota the first instars do not possess wings at all. The only reasonable conclusion seems to be that wings have been secondarily acquired in the Insecta, and it is tempting to regard these truly apterous instars as reminiscent of the original apterous condition. This, of course, in no way proves that those groups of Insecta which entomologists have seen fit to place in the group Apterygota are themselves primarily wingless. But it does indicate that the earliest insects were apterous, and suggests that Thysanura, Protura and possibly Collembola may well be their survivors.

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CHROMOSOME CONJUGATION IN HYBRIDS BETWEEN *DROSOPHILA MELANOGASTER* AND *DROSOPHILA SIMULANS*

STERILITY of interspecies hybrids is for the most part explained as a consequence of incompatibility of the hereditary material (chromosomes) in the species crossed, of such a nature as to lead to disturbances in the normal conjugation of the chromosomes. This point of view is supported by the phenomena in plant hybrids having duplicated chromosome sets, where each chromosome finds a partner and the fertility of the hybrids is restituted. Evidence showing that in animals we find a different condition, were presented by Dobzhansky (1933, 1934) who found tetraploid regions of tissue in the testes of interracial *D. pseudoobscura* hybrids. This author suggested that in animals factors of other kinds enter in as well, to determine the interspecies sterility. Investigations concerning the cause of the disturbances in chromosome conjugation in species hybrids remain, however, of great interest because of their bearing on the more general problem of the sterility of such hybrids and on the problem of the splitting of species in evolution.

A series of questions in connection with chromosome behavior can be attacked by the study of hybrids between *Drosophila melanogaster* and *Drosophila simulans*. Thus, in the earlier work in this field it was shown by comparative genetic and cytological analysis of the two species (Sturtevant and Plunkett, 1926; Sturtevant, 1929) that not only did these species differ in regard to the Y-chromosome, but also in regard to the order of the genes in the third chromosome, where a long section is inverted. The modern conception of the mechanism of chromosome conjugation might lead us to suppose that such incompatibility in the structure of the homologous chromosomes could in some cases disturb the conditions of normal conjugation and thus cause sterility in the hybrids. The latest works of Painter (1933, 1934a, 1934b), of Bridges (1935) and of Muller, Prokofyeva and Raffel (1934, 1935) on the salivary gland chromosomes of Drosophila have opened up a great field in the study of the finer structure of these chromosomes and of their conjugation. Moreover, the conjugation of the chromosomes in these cells enables us to investigate very exactly the structure of the two conjugating homologues,

as well as their attractive force, which is very probably of the same nature in both meiosis and mitosis.

The present paper gives an account of the preliminary results obtained in a study of the conjugation of the chromosomes—principally the X—in salivary gland cells of *melanogaster-simulans* hybrids. The material for the experiment consisted of fully grown female larvae, dissected only a few hours before the stage of pupation. Larvae of both parent species, of the same age, were used as controls.

In the larvae of both parent species, practically all the chromosomes were found to have already conjugated over their entire length, at the stage of development studied, only short unconjugated portions being occasionally seen. In contrast to this, the hybrids were found to show a very much lessened tendency to conjugate, on the part of all the chromosomes. This decrease in conjugation, which can not readily be expressed quantitatively, is evident from the fact that as a rule all the chromosomes in all the cells have rather long unconjugated regions as well as regions showing all transitional stages between complete conjugation and complete lack of conjugation. This incompleteness of conjugation is especially apparent at the distal (free) ends of most of the chromosomes, where it is expressed by a greater or lesser degree of forking. In the case of the X-chromosome, on which our attention was chiefly concentrated in the present experiment, we were unable to discover any regions except the distal end in which conjugation regularly failed to occur. But the distal end was always forked, for the space of the first ten to eleven bands, even in those cases in which the rest of the X-chromosome conjugated throughout the major portion of its length.

In order to obtain evidence concerning the relative attractive forces acting between the chromosomes of the hybrids and of the pure species under somewhat different conditions, which might favor the recognition of a weakening of this force, I have undertaken a comparative study of the formation of the loops in salivary gland chromosomes in individuals heterozygous for the inversion known as delta 49. It was found that in hybrids of *D. melanogaster* and *D. simulans,* containing this inversion in the X-chrososome derived from *melanogaster,* the conjugation of the chromosomes in the region of the inversion is usually confined to a short section, and even in this section the fusion between the two chromosomes is sometimes very incomplete. On the other hand,

in females of *D. melanogaster* which are heterozygous for the delta 49 inversion or other inversions, the chromosomes nearly always conjugate completely in both non-inverted and inverted regions, even up to the point of rearrangement, despite the fact that we should expect to find the conflict of attractive forces to be greatest at this point. This then affords strong corroboration of the fact of weaker conjugation in the hybrids.

We may now turn our attention to the different possible explanations of the weakened conjugation found. It is not improbable that outside of the already known gross differences in the Y and third chromosomes of *D. melanogaster* and *D. simulans* above referred to (paralleled by the gross rearrangements noted by Tan (1935), distinguishing different races of *D. pseudoobscura*), there are some other, much minuter rearrangements, causing non-correspondences in the homologous chromosomes, like those first demonstrated by Muller, Prokofyeva and Raffel (*ibid.*) in the case of certain mutations of *D. melanogaster*. Evidence of the probable existence of one such rearrangement in the left end of the X-chromosome of normal *D. simulans,* as compared to *melanogaster,* was in fact found by Kossikov in some parallel work, as yet unpublished, and there are similar unpublished data of Dobzhansky on different races of *D. pseudoobscura* (*ex lit.*). It might at first be supposed that the effect of these minute rearrangements would not be sufficient to break the normal somatic pairing in the metaphases of the hybrids, but that in their totality they would be responsible for the decrease in conjugation in the salivary cells. It is, however, very unlikely that such rearrangements are in themselves sufficient in number to account for all the observed decrease of conjugation, for careful comparison has revealed few of them and if many were present there should be not a few large enough to be readily apparent. It is often possible to observe complete symmetry in the structure of the partner chromosomes in unconjugated regions of the hybrids. This gives the impression that there is a decrease in the effectiveness of the attractive force conditioned by some other factor or factors besides the factor of gross and minute gene rearrangements (inversions, translocations, etc.).

A second way in which the attractive force between the homologous chromosomes of hybrids may have become weakened is by the occurrence, during the course of the evolution of the two species from their common ancestor, of mutations in the compo-

sition of individual genes. As was pointed out by Muller as far back as 1918, and later elaborated by Dobzhansky (1931) and others, the attraction between homologous chromosomes must depend upon a specific attraction between the individual gene loci, like attracting like, and so in the case of any originally homologous chromosomes that have become differentiated from one another by gene mutations, the force of conjugation should be weakened. It may be possible to gauge the importance of this cause of decreased conjugation by a process of elimination, after the rôles played by the other factors have been ascertained and allowed for.

But the two factors above considered, namely, (1) non-matching of the chromosomes caused by gene rearrangement and (2) non-matching caused by mutations in individual genes, are not the only causes of the weakened or disturbed conjugations of chromosomes in hybrids. The author has shown that in hybrids of Drosophila, the disturbance of the development of the sexual glands begins much earlier in ontogenesis than those stages in which the synapsis of the chromosomes takes place (Kerkis, 1933, 1934). And the experiments of Schultz and Dobzhansky (1934) on triploid hybrids of *D. melanogaster* and *D. simulans* which have two sets of chromosomes from the former species and one set from the latter, have shown that conjugation is lacking in them also, notwithstanding the presence of a pair of homologous chromosomes derived from one of the species, and these hybrids also have reduced gonads and are entirely sterile. In crosses between different species of Sphingidae, in which the hybrids produce very much reduced oocytes that fail to reach full maturity, Bytinski-Salz (1934) managed to obtain normal development of the ovaries of the hybrids and full maturation of the eggs, by transplantation of the hybrid ovaries from the hybrid pupae into the pupae of one of the parent species. In this way it was shown that the initial causes of sterility here lay outside of the sex glands and their chromosomes, and depended upon characteristics of the soma of the hybrid itself. On the other hand, in crosses between other species of Sphingidae carried out by the same author, transplantation of the reduced hybrid ovaries into the soma of one of the parent species resulted in an apparently normal growth of these ovaries, but not in the complete maturation of their egg cells. In this case the determination of the sterility was more complicated.

In cases like the above it is probable that the sterility in general and along with it the defectiveness of maturation, including the incompleteness or failure of chromosome conjugation, is dependent upon physiological conditions in the germ cells that do not result from a non-matching of chromosome regions or allelomorphic genes *per se,* but from a malfunctioning of the two sets of genes in their relations with one another. That is, the genes from one species have not been selected, in the course of evolution, so as to give reactions which fit in sufficiently well with the reactions caused by the genes of the other species, and the delicate organization necessary to ensure normal maturation and conjugation is upset in the individual having both sets of genes. This is only a description in other terms of a commonly held view that sterility depends upon a general genetic disharmony, or, as it is sometimes expressed, upon "complementary genes" from the two species, lying in different loci, which together act to cause the sterility. Examples of specific mutant genes of such a kind, innocuous in the species in which they were originally found but harmful in the presence of a set of chromosomes of the other species, have been described on various occasions (see, for instance, the discussion by Dobzhansky and Boche (1933) and Dobzhansky (1934) in connection with their work on the sterility of interracial hybrids of *D. pseudoobscura*). It need not be assumed that all the mutations giving rise to such incompatible effects are necessarily changes in the inner position of the genes, for of course changes in gene expression caused by the "position effect" of gene rearrangements may also be expected to work in similar fashion.

The conclusion may, therefore, as it was suggested by Dobzhansky (1934) be drawn that the possible causes of disturbance in the conjugation of chromosomes in hybrids may be very different in different cases, and that in fact various of these causes may be acting at once. It likewise follows that the the mechanism of causation of hybrid sterility may be very different in different cases. In the case of the *melanogaster-simulans* hybrids it will be possible to determine whether the reduction in the force of conjugation is a direct result of the unlikeness (in gene quality or gene order) between homologous chromosome parts, or depends upon changes in properties of the protoplasm, caused by the disharmonies aroused by incompatible genes in different loci. Experiments designed to answer this question are now being carried out.

The author wishes to express his sincere thanks to Dr. H. J. Muller for going over the present manuscript.

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ATYPICAL GROWTH

THE mutation theory to account for the onset of atypical growth in animals and plants has been proposed from time to time. In a recent book entitled the "Origin of Cancer," Mr. Lockhart-Mummery (1934) has assembled evidence from many sources. As senior surgeon at St. Mark's Hospital and editor of the Annual Report of the British Empire Cancer Campaign he is in a favorable position to summarize the facts from the field

of medicine. The genetic and cytological evidence bearing on this problem is so recent and so fragmentary that biologists will hesitate to accept this theory as adequate until more critical experimental evidence is available.

The author states his thesis in concise form: "Cancer is the result of a genetic change in a normal growing somatic cell." A malignant tumor is one manifestation of atypical growth that occurs in both animals and plants and as such is much more than a problem in pathology. Fasciations and galls in plants, neoplasms, monsters, teratological phenomena of many kinds in animals are related phenomena. Experimental embryologists have concerned themselves largely with normal growth. A study of abnormal growth may also prove useful to understanding those processes by which living organisms attain their many diverse forms.

In 1902, Boveri suggested what may be called the aberrant chromosome theory of cancer formation. This was later elaborated into a book and translated into English (1929) with the title "The Origin of Malignant Tumors." Boveri observed multipolar mitoses in double-fertilized sea-urchin eggs. The unequal distribution of the chromosomes to the daughter cells in some cases was followed by abnormal growth, resulting, he thought, either from an excess or deficiency of the normal amount of chromatin. The initial agencies responsible for the assumed unusual distribution of chromosomes in tumor formation were not made clear. While irregular mitoses are common in tumor cells later investigations have shown abnormal growth where no irregularity is visible.

That there are growth-regulating genes in the chromosomes having an effect upon the number, size and arrangement of cells is conclusively proved by evidence from many sources. These genes are capable of normal transmission and recombination according to the known rules of heredity. The infrequently occurring mosaics in both plants and animals show that changes in the genetic constitution in different parts of the organism may result in differences in growth. The fowl mosaics recently described by Roberts and Quisenberry (1935) and some of the plant chimeras are illustrations. White (1916) has reviewed the evidence showing that some fasciations in plants are genetic alterations of some kind (presumably mutations) that are transmitted to succeeding generations. Others seem to be merely temporary

effects of environmental influences and are not transmitted either by seed or vegetative propagation. Tumors in Drosophila are the result of mutant genes or some similar genetic change (Wilson, 1924; Stark and Bridges, 1926). Galls occur in plants from outgrowths of cambium tissue when no infectious organism or external agent, so far as known, is present, as shown by Brown (1924).

Lockhart-Mummery has summarized the evidence from animal tumors to show that they are not due to infectious organisms; that they can not be transplanted by a cell-free filtrate; that they originate only in growing tissue from one or a few cells; that there is no universal external agency that can instigate abnormal growth in all organisms; and that there is some evidence for an inherited tendency to tumor formation as shown by family studies and identical twins. He also points to the significant fact that frequency of tumor formation is increased by physical, chemical and biological agents that also increase the frequency of gene mutation and chromosomal aberration. Summing up his argument briefly: There is little evidence that refutes the possibility of a genetic change as the starting point of atypical growth and much evidence that points directly to the alteration or loss of growth-regulating genes as the primary factor. Avian and rodent tumors form exceptions to this conclusion. Cell-free filtrates from tumors in these animals are known to produce neoplasms of a similar nature in other individuals of the same species and these are capable of transplantation.

Many inherited factors are known that affect the size and shape of different parts of organisms and these are essentially growth-regulating genes. Vital processes can be changed but little and still permit life. The large number of lethal mutations bear witness to this. Some of these lethal gene changes permit growth of the embryo up to varying stages approaching normality. But there is no adequate experimental evidence to show that dominant mutations of growth-regulating genes occur with sufficient frequency or are of such a nature as to account for the number of neoplasms that are found in nearly all forms of life. Recessive mutations would not show in somatic tissue until their normal alleles were also changed or removed and would also be transmitted to the following generations. A large number of atypical growths occur with no indication that there is any tendency for their recurrence in later generations.

Many questions therefore remain concerning the nature of the genetic change that may initiate unregulated growth as well as the internal and external agencies that may induce them. Germinal changes capable of recombination may be brought about in various ways: gene alteration in constitution or position, gene multiplication or gene loss.

The distinction between gene alteration and gene loss is becoming less clear. Changes that were formerly thought to be mutations are now known to be small deficiencies or changes in position (Stadler, 1932; Muller and Prokofyeva, 1935). Genic alterations (mutations) that are not accompanied by any visible difference in the region of the chromosome wherein they reside are presumably the result of some physical or chemical change in the gene itself. Changes of this kind affect many growth-regulating processes in both animals and plants.

Gene multiplication results from aberrant chromosome distribution, resulting in a duplication of parts or of whole chromosomes. It is known that this has a marked effect on many characters, particularly sex expression. There is some tendency for duplication to augment size. But there is little to indicate that unregulated growth may result from this process.

Gene loss is indicated by the deficient areas that are easily seen in the salivary gland chromosomes in Drosophila (Metz, 1934) and in maize at the mid-prophase stage of meiosis (McClintock, 1931; Stadler, 1933). The genetic evidence also proves that genes have been removed from the cells in some of these cases.

If for any reason a gene loses the ability to propagate itself without stopping normal chromosome and cell division this gene will be lacking in all but one of the resulting cells. Losses of single genes in this way by inactivation may bring about no visible change in the chromosome. Single bands are known to be missing from salivary gland chromosomes without altering appreciably the size or shape of the chromosome. In less favorable material such losses may seldom or never be detected by present means of investigation. These small losses are more likely to permit growth and development than visible deficiencies or other chromosome aberrations.

Demerec (1934) has shown that most homozygous deficiencies are lethal to the cells in which they originate. But not all deletions of this kind are lethal, and possibly some that involve one or a few particular genes may permit growth in an unregulated

manner. It has been shown (Van Overbeek, 1935) that the dwarf gene in maize produces its effect by destroying a growth-stimulating hormone. We may assume that similar changes occur in the opposite direction, increasing the amount of growth-stimulating substances either by gene alteration or loss. Normally these accidents are guarded against by the duplicate gene system. But when such a change occurs in one of the paired genes there is always the possibility that the normal allele may be lost in somatic tissues by non-disjunction, corresponding deficiency or by somatic crossing-over.

The effects of somatic synapsis and crossing-over in the four-strand stage have been described by Serebrovsky (1925) in fowls and by Demerec (1934) and Stern (1935) in Drosophila. The twin spotting in Drosophila, maize pericarp, fruit and flower epidermis is interpreted on the basis of somatic crossing-over, non-disjunction or other chromosomal aberrations. Mosaics showing tissues of different color and texture are easily seen in maize endosperm. In heterozygous material they may be the result either of non-disjunction, of deficiency of a dominant gene or of somatic crossing-over. Mosaics have been found in homozygous material and could not be due to crossing-over without some previous change. Twin spots have been found in maize aleurone color in the form of dark purple and non-colored areas where the surrounding tissue is light-colored. Either non-disjunction, deletion and somatic crossing-over therefore may remove the normal protecting genes and permit the recessive or missing genes to produce an effect in somatic tissue.

Mosaics involving the same genes vary markedly in frequency with different stocks (Jones, 1935), showing that there are probably many factors, internal and external, that affect the rate of their occurrence. The evidence is clear that they may result without any known external agent and are increased in frequency by the same chemical, physical and biological agencies that also increase the frequency of neoplasms.

The varying frequency of mosaic formation is paralleled by the sporadic occurrence of atypical growth in plant and animal tissue. Definite overgrowths have been found in maize plant and endosperm tissue. These are not associated with any gene alterations so far known but are of the same nature and order of frequency as mosaics involving known genetic characters.

Some malignant tumors lose their ability to grow abnormally and gradually revert to healthy tissue. Lockhart-Mummery assumes that reverse mutation has taken place in these cases. Mass mutation of this kind involving many cells is a far different matter than a change in a single cell at the start and has no basis in genetic evidence. Other explanations seem more plausible.

Carcinogenic chemicals, x-rays, radium, ultra-violet light and other physical agents, plant and animal excretions, all apparently have their effect indirectly either by inactivating specific genes or by bringing about chromosome aberrations in greater numbers so that genes are either changed or removed from certain cells without destroying the ability of these cells to divide. This would account for the delayed action of all external agencies and shows why no influence from the outside can do anything more than what may occur sporadically in the organism itself. Tumor extracts seem to have the ability to affect specific genes. The gall-forming insects, nematodes, fungi, bacteria and other organisms also have the power to change plant growth in certain definite directions. It seems plausible that all these agencies have their effect by acting indirectly through the genes either by stimulation, inactivation or deletion from the chromosome.

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SIX RECORDS OF THE POINTED-TAILED OCEAN SUNFISH NEAR HAVANA, CUBA

THE apparently rare fish, the pointed-tailed Ocean Sunfish (*Masturus lanceolatus*) reported locally as *Mola mola*, has been caught on several occasions in northern Cuban waters.

The first on record was taken in February, 1913, off the mouth of Almendares River, west of Havana City. Upon the capture of this fine specimen, Dr. Carlos de la Torre, professor of zoology at the University of Havana, had his assistant, Dr. Victor Rodriguez, make a cast of it. The color given to the cast was taken from the original specimen, and the cast is now in the "Museo Poey" in the University of Havana. It is over five feet long and shows perfectly well the pointed tail so characteristic of the species, as well as the spots that cover the whole body. This specimen was for many years identified as *Orthagoriscus mola* until the visit made to Havana in 1933 by Mr. Henry W. Fowler, who correctly named it. (See Fig. 1).

In 1923, another fish about the same size was caught at Matanzas. As stated by Dr. Rodriguez, a mould for a cast was made from this one also. Unfortunately, it was ruined afterwards, but the pointed tail of the fish as well as its spotted body

were identical with the first sunfish, details he distinctly remembers.

On October 6, 1932, a specimen weighing 200 pounds and measuring more than three feet in length was caught with a harpoon in the open sea off Havana Harbor. Although I saw this specimen I was not able to make measurements, as it had been cut to pieces by the fishermen who brought it in, nevertheless its prolonged middle caudal rays with the rounded point, together with other minor details, were sufficient to make me certain that it was another *Masturus*. One of the fishermen,

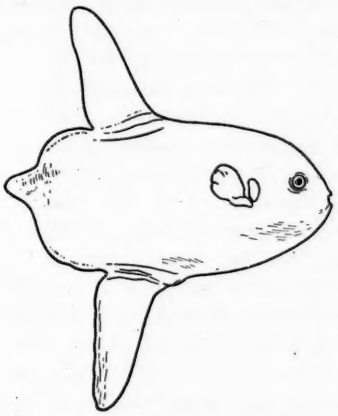

FIG. 1. Outline sketch of the model of *Masturus lanceolatus* in the Museo Poey of the University of Havana.

upon seeing the greasy flesh, cut up the fish and tried to obtain oil from it, but without success.

Early in the morning of September 10, 1934, another specimen was taken at "La Chorrera," a little to the west of Havana City, and at the end of its suburb Vedado.[1] It came in shore at high tide in the shallow water at the mouth of Almendares River, but when the tide began to ebb it was unable to swim out again. The flapping of its fins attracted the attention of several fishermen around the place, who, thinking it was a devil-fish, *Manta*, caught it with a harpoon.

This specimen was seen fresh that same morning, and the following notes, as well as a sketch, were taken on the spot:

[1] *Mem. Soc. Cub. Hist. Nat. "Felipe Poey,"* Vol. VIII, 1934, No. 6, p. 338.

Total length to tip of caudal, 58 in.; height from tip of dorsal to tip of anal, 69 in.; length from tip of snout to gill opening, 13 in.; length from tip of snout to vertical of vent, 29½ in.; width of head, 10 in.; horizontal diameter of eye, 2⅛ in.; vertical diameter of eye, 1⅞ in.; pectorals, 4½ in. long, rounded; height of dorsal in total length, 2⅝ times; height of anal in total length 2¾. Eye nearer to tip of snout than to gill opening. Body narrower than the head. Gill openings forming a small semicircular slit. No apparent separation between the membrane of the dorsal, anal and caudal fins; the rays of the fins were not counted, as the thickness of the skin made this impossible. The tail was thick and rough, even to its median rays; these were extended beyond the vertical of the rest of the fin, forming a marked lobe which gradually decreased in size to its rounded point. Sides and ventral surface of body silvery, with scattered dark spots, most numerous on the belly; dorsal, anal and caudal fins black, with large bluish-white spots on their bases; pectorals white. Approximate weight 400 pounds. When opened the specimen showed greasy, whitish flesh, and white cartilaginous bones, even the beak formed by the jaws being so soft that it could be cut with a pen-knife, though it was the hardest part of all. The tongue was wide and hard, suggesting that it is used to crush its food against the palate. The liver was large, light brownish, the stomach small, muscular, empty at the moment; the intestine quite long, with several convolutions. The skin was leathery, thick, very rough; the scales with a narrow, long, oblong base and several prominent conical cusps, each of which ends in several points. The number of the cusps as well as the number of points to each is widely variable. Under the epidermis where the scales are implanted, there is about an inch of thick, white, leathery substance, giving the whole the appearance of a "hide" which looked fatty, but yielded no grease on heating or boiling. A curious detail, as stated in "Memorias" (*loc. cit.*), was that the liver and intestines were full of worms, some of them still alive when the fish was opened. This material is being studied in order to determine the internal parasites of this rare fish.

This specimen, as well as the one seen in 1932, on being compared with the cast at the University of Havana, appear to be closely identical in form, but differ somewhat in coloration. The fresh specimen has a silvery color on sides and ventral surface

of the body, a color which the cast lacks, but this can be explained by the fact that when the skin dries, the silvery tone fades out, leaving the skin grayish, the color which was applied to the cast. I was able to ascertain this, as a sample of the skin was kept from this last specimen and all its silvery color faded out in a short time.

A few days after the above fish was caught, two others were seen around the same locality. I had gone out for a row without intending to fish and so had no harpoon at hand when the two specimens, swimming lazily, passed near. They were approximately of the same size as the one caught some days before. As they slowly swam in the clear water with the tips of their dorsal fins above the surface, I could distinguish the lobe of the caudal fins. The light on their silvery sides yielded metallic reflections, and the bluish dots on the posterior part of the body seemed more intense. One of them had its dorsal fin mutilated, and a scar could be seen along one of its sides; probably the result of an attack by some shark.

Knowing that *Masturus* is a rare fish and confused with *Mola*, I inquired among the fishermen if they had seen any other "sunfish" with a rounded tail, that is, without a point. One of the oldest in the place informed me that his recollection of the few he had seen was that they all had pointed tails, that their unpaired fins were black and that they were marked with bluish dots, thus supporting the view that the true *Mola* is rarer than *Masturus* in Cuban waters.

Summing up the available data, four specimens have been caught at intervals, the two last late in the years of 1932 and 1934. These, with the two I saw and recognized, give a total of six specimens reported from our northern coast. So far as I know, no small specimen has ever been caught or reported in Cuban waters.

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EFFECTS OF CHLORINATED CITY WATER AND LACK OF FOOD ON COMET GOLDFISH

RECENTLY, an experiment was concluded in my laboratory which may be of interest to biologists and goldfish fanciers and breeders. On June 29, 1934, a lady residing in Corvallis brought into my laboratory two comet goldfish (*Carassius auratus*), which she had had in an outdoor pool back of her home, to find out what seemed to be the matter with them, as her fish were

not doing well, and a number of them had already died. This lady was sure that the chlorinated city water was injurious to her fish and was killing them off.

On examining the comets I found that they were parasitized with the copepod, *Argulus trilineatus* Wilson, and also by the fungus, *Saprolegnia,* which was eating away their pectoral and tail fins. The fish also were sluggish, due largely to overfeeding. After diagnosing what seemed to be wrong with the fish they were left with me, and I determined to find out if possible, first, how long comet goldfish can be kept without food, in an aquarium of running, chlorinated city water, and secondly, what particular effect the small amount of chlorine ordinarily supplied city water would have on them.

Before placing the fish in the water the parasitic copepods were removed from them. The water supplying the aquarium was kept running constantly and was part of the normal supply of drinking water of the city of Corvallis, which, every twenty-four hours, utilizes approximately 2,250,000 gallons of water, into which has been impounded ten and one-half pounds of chlorine and two and one-half pounds of ammonia. These chemicals are impounded into the water at the intake, approximately five miles distant from the city of Corvallis.

Throughout the entire experiment no food in any form was supplied the fish. While some food may have been obtained through small organic particles brought in by the stream of city water, still the amount obtained must have been so small that it was really negligible, since the water at all times seemed perfectly clear, with almost no sediment.

Shortly after the goldfish were placed in the aquarium the *Saprolegnia* completely disappeared from both of them, and their fins healed completely. Moreover, both fish seemed perfectly normal, healthy and active until a few days before their death. The first comet lived in this environment continuously from June 29, 1934, to November 5, 1934, when it died—approximately four months and seven days. The second comet lived considerably longer, from June 29, 1934, to January 26, 1935, when it died—a period of six months and twenty-seven days. As far as appearance and general behavior, the fish seemed in no way affected by the insignificant amounts of chlorine and ammonia in the inflowing water. Undoubtedly, death was due entirely to starvation.

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